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ABSTRACT

Physical and Earth Science AB, a required senior high school course in the Los Angeles Unified School District, uses an investigative approach for developing scientific understanding and attitudes for students. Contents include: (1) summary of representative objectives; (2) teacher responsibilities; (3) the agenda; (4) guidelines for assignment of homework; (5) how to use this outline; (6) time schedule and sequence of units; (7) required skills and concepts (containing the objectives, content outlines and continuum skills for 10 units of study); (8) teacher-directed instructional sequences (providing 10 sample lessons with activities); (9) teaching strategies; (10) categories of thinking and suggested verbs for use in stating cognitive outcomes; (11) evaluation procedures; and (12) tips for parents. Appendices consist of the answer key and scoring and testing procedures for the classroom test of formal operations, a list of resources, and the secondary science continuum for the Los Angeles Unified School District. (ML)

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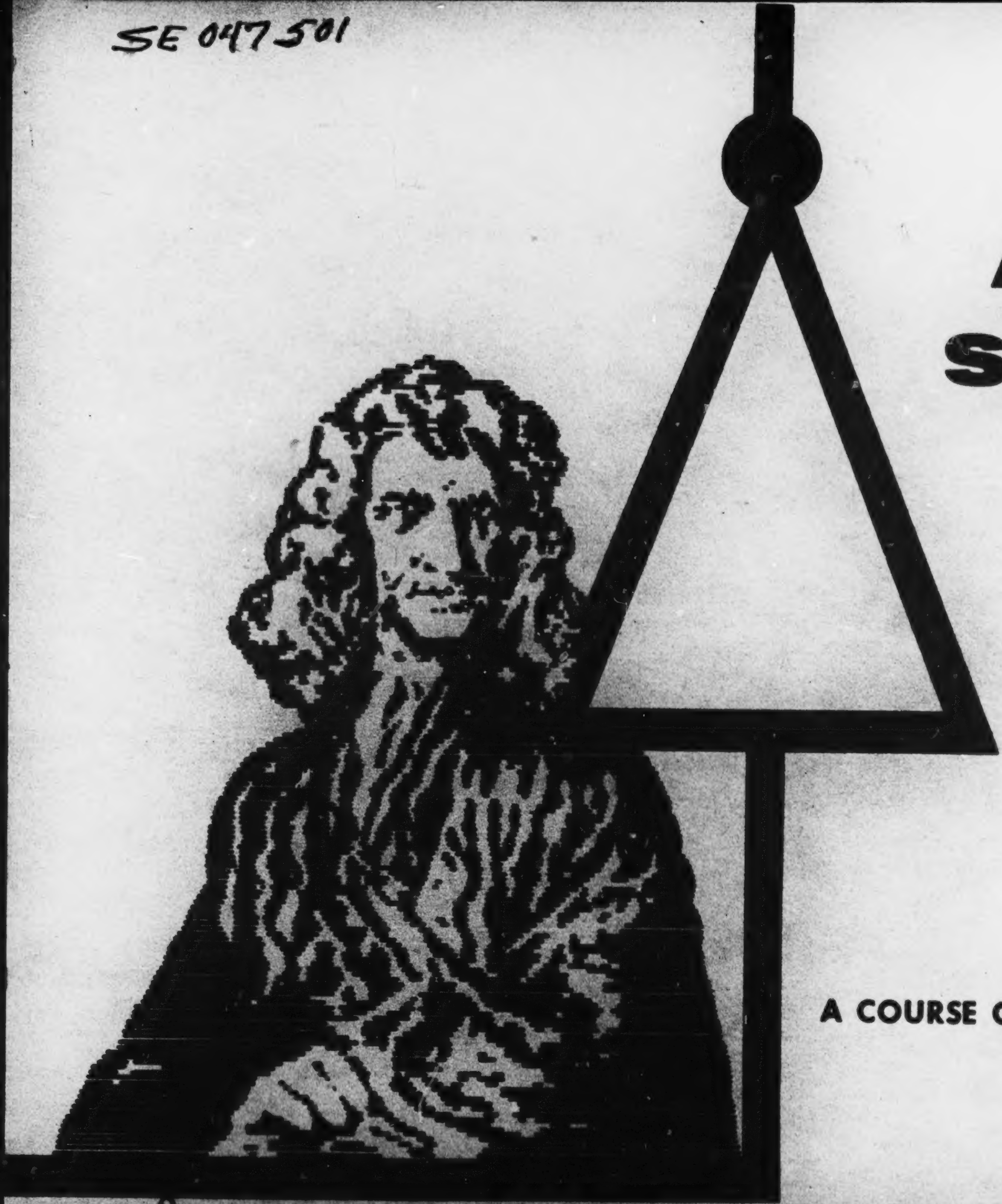

PHYSICAL AND EARTH SCIENCE AB

GRADES 9 – 12

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A COURSE OUTLINE FOR SENIOR HIGH SCHOOLS

LOS ANGELES UNIFIED SCHOOL DISTRICT
Office of Secondary Instruction
Publication No. SC-874 1985

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PHYSICAL AND EARTH SCIENCE AB

Grades 9-12

A Course Outline for Senior High Schools

LOS ANGELES UNIFIED SCHOOL DISTRICT
Office of Secondary Instruction
Publication No. SC-874 - 1985

THE COVER

The portrait of Sir Isaac Newton (1642-1727), the great classical physicist, was done by Michael Harp of Bell High School. The triangular object at Newton's elbow is the electronic symbol for an inverter component of an integrated circuit, representing the state-of-the-art applied physics of today.

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Los Angeles Unified School District

FOREWORD

Scientists acquire and organize knowledge in order to explain natural phenomena and to increase their usefulness to humankind. Through the science instructional program in secondary schools, students develop an understanding that science is a body of knowledge comprised of interconnected sets of principles, laws, and theories that explain the known universe and our relationship to it. Students investigate phenomena systematically and acquire and refine information. Outcomes include a greater understanding of how human beings use scientific information essential for comprehending our environment and for reaching solutions to problems of daily living.

Physical and Earth Science AB, a required senior high school subject, is designed to help the student develop a basic knowledge of science and the appropriate skills, learning processes, and attitudes. These outcomes are emphasized because they are fundamental to good citizenship and effective participation in today's society.

The science program includes a study of physical and earth science with particular emphasis on an investigative approach to developing scientific understandings and attitudes. This outline also contains an introduction section on skills and concepts which has important applications for instruction throughout the course.

ACKNOWLEDGMENTS

Gratitude is expressed to those individuals who contributed to the development of this instructional outline by reviewing the content, suggesting changes in the course descriptions and objectives, and recommending unit titles and concepts.

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Mary Ann Sesma, Assistant Principal, Bell High School

who organized the suggestions of teachers and advisers and wrote the instructional course outline, incorporating ideas and lessons drawn from classroom experiences.

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SUMMARY OF REPRESENTATIVE OBJECTIVES

Unit Title	Objectives
SKILLS AND CONCEPTS REQUIRED AND DEVELOPED IN PHYSICAL AND EARTH SCIENCE AB	- Assemble and use laboratory apparatus, tools, and materials in a skillful manner, giving due attention to safety measures.
	- Develop ability to generate data by observing, recalling, recognizing, identifying, and measuring.
	- Prepare a laboratory report.
	- Gather information from the library and other appropriate sources.
Unit One	
MECHANICS	- Distinguish between the kinematic variables: speed, velocity, acceleration, distance, and displacement.
	- Be able to predict the changes in motions of objects using Newton's three laws of motion.
	- Be able to distinguish and give examples of kinetic and potential energy.
	- Be able to define and differentiate between work, force, and power.
	- Describe and predict the functions of simple machines as illustrations of Newtonian mechanics.
	- Relate the consistency of a physical event with a physical law.
	- Accept responsibility for the safe and careful handling of laboratory materials and equipment.
	- Identify and describe careers at various levels in the physical sciences.

Unit Title	Objectives
Unit Two WAVES	- Describe the properties of waves. - Differentiate between reflection and refraction. - Compare the refraction of light by two different types of lenses. - Relate the properties of light and sound to the processes of seeing and hearing. - Relate the consistency of a physical event with a physical law. - Accept responsibility for the safe and careful handling of laboratory materials and equipment. - Identify and describe careers at various levels in the physical sciences.
Unit Three ELECTRICITY AND MAGNETISM	- Describe the proton, neutron, and electron model for the atom. - Relate static electricity to the model of the atom. - Formulate relationships between current flow in a circuit with the atomic model. - Define and measure at least three electrical units: e.g., ampere, ohm, and volt. - Compare and contrast alternating and direct currents. - Describe several magnetic effects. - Relate the properties of magnetism to charges in motion.

Unit Title	Objectives
Unit Three (Continued) ELECTRICITY AND MAGNETISM	- Relate the consistency of a physical event with a physical law. - Accept responsibility for the safe and careful handling of laboratory materials and equipment. - Identify and describe careers at various levels in the physical sciences.
Unit Four PROPERTIES OF MATTER	- Describe concepts involved in matter and its changes. - Describe models of atoms. - Relate the consistency of a physical event with a physical law. - Distinguish between an element, a compound, and a mixture. - Interpret the Periodic Table. - Accept responsibility for the safe and careful handling of laboratory materials and equipment. - Identify and describe careers at various levels in the physical sciences.
Unit Five NUCLEAR ENERGY	- Recognize the history of nuclear energy. - Describe the concepts involved in matter and its changes. - Relate the consistency of a physical event with a physical law. - Describe the properties of radiation.

Unit Title	Objectives
Unit Five (Continued) NUCLEAR ENERGY	- Distinguish between nuclear fission, fusion, and breeder reactors. - Assess the political, military, and health issues of the nuclear age. - Accept responsibility for the safe and careful handling of laboratory materials and equipment. - Identify and describe careers at various levels in the physical sciences.
Unit Six DESCRIPTION OF THE LITHOSPHERE	- Describe the layers of the lithosphere. - Distinguish between the three different rock forms: igneous, sedimentary, and metamorphic. - Utilize simple tests to identify various minerals. - Identify and relate certain fossils with the age of the earth. - List several uses for minerals. - Identify and describe careers available in the geological sciences. - Accept responsibility for the safe and careful handling of laboratory materials and equipment.
Unit Seven GEOLOGICAL PROCESSES	- Distinguish between the processes of erosion, weathering, and deposition. - Recognize that earthquakes can occur in populated areas and can cause extensive damage to life and property.

Unit Title	Objectives
Unit Seven (Continued) GEOLOGICAL PROCESSES	- Analyze the relationship between the locations of earthquakes and volcanoes. - Describe in terms of continental drift, plate tectonics, and sea-floor spreading, the geological forces acting on the earth. - Accept responsibility for the safe and careful handling of laboratory materials and equipment.
Unit Eight THE HYDROSPHERE	- Describe the composition of ocean water. - Describe the major topographic features of the ocean's floor. - Describe the effects of wind, the earth's rotation, the moon, and the sun on the ocean currents and the tides. - Recognize the value of natural resources found in the ocean. - Analyze the parts of the hydrologic cycle. - Recognize the importance of fresh water as a natural resource. - Identify and describe careers available in the field of oceanography. - Accept responsibility for the safe and careful handling of laboratory materials and equipment.

Unit Title	Objectives
Unit Nine THE PROPERTIES OF THE ATMOSPHERE AND THE PROCESSES OF WEATHER	- Describe the parts of the atmosphere. - Identify and describe the properties of the atmosphere and their effects on the weather. - Recognize the use of various scientific instruments to collect meteorological data. - Interpret the symbols on a weather map. - Describe how severe storms can cause great damage to people and property. - Recognize that weather predicting is both a difficult and important task. - Identify and describe career opportunities in meteorology. - Accept responsibility for the safe and careful handling of laboratory materials and equipment.
Unit Ten THE UNIVERSE AND SPACE	- Describe the tools used by astronomers. - Describe the different members of the galaxy and the solar system. - Classify stars according to their absolute magnitude and temperature. - Analyze the cause and effect relationship between the earth, moon, sun, and tides and eclipses. - Describe the physical features of the moon.

Unit Title	Objectives
Unit Ten (Continued) THE UNIVERSE AND SPACE	- Recognize that space exploration was done by many different people. - Identify and describe careers available in astronomy and the space sciences. - Accept responsibility for the safe and careful handling of laboratory materials and equipment.

TEACHER RESPONSIBILITIES

The teacher is responsible for creating, maintaining, and fostering a classroom environment and a climate for learning which encourages instructional excellence and achievement. In order to maintain such an environment successfully, the teacher is responsible for:

1. Providing students and parents with a clear statement of instructional objectives, overall goals, and standards of expected progress and achievement.
2. Providing instruction which incorporates a diagnostic-prescriptive program for learning all required skills and concepts.
3. Following the time line as closely as possible, preparing instructional activities for the entire class period and assisting students in striving for mastery of content and process skills.
4. Having evidence in the classroom of lesson planning to meet the educational needs of the students and the goals of the instructional program.
5. Providing regular instruction and practice in preparing students to take and succeed on tests and other measures of achievement.
6. Maintaining well-defined and consistent classroom standards for academic achievement, citizenship, and work habits.
7. Providing regularly assigned homework designed to reinforce classroom instruction.
8. Providing students and parents with an explanation of the standards used for assigning marks.
9. Providing prompt feedback to students on the results of quizzes, homework, and other class assignments.
10. Recognizing individual student progress and exceptional achievements; displaying student accomplishments and products in the classroom.
11. Recording a minimum of one grade per week in the rollbook for each student.
12. Keeping parents regularly informed of the educational progress and achievement of the student.
13. Informing parents of outstanding progress and accomplishment.

14. Notifying parents of any signs of significant academic decline in student effort or achievement.

15. Providing parents with suggestions on how to help the student study and complete homework assignments.

16. Inviting administrators, department chairpersons, and fellow teachers to visit the classroom and participate in a sharing of effective and innovative lessons.

THE AGENDA

An agenda, or schedule of class activities, prominently displayed in the classroom, gives immediate directions to the students and prepares them for the day's classwork. The agenda should include an objective, a dispatch activity, scheduled class activities, and homework assignment. The agenda may be written on the chalkboard. Some teachers, particularly teachers who travel from classroom to classroom, prefer to use chart paper that can be easily taped or pinned to a board and quickly removed to be used in a new location. A good way to evaluate an agenda is to ask the question "If a student were absent, could he or she read the agenda and know what happened in the classroom today?"

The dispatch activity is an essential part of the agenda. It should be a short, written, timed exercise that students start as soon as the period begins. Students should be able to complete the dispatch without teacher assistance. The dispatch is used to:

- review and reinforce concepts and ideas previously studied
- start students working immediately upon arrival in class
- preview or introduce new work
- establish a routine
- allow the teacher an opportunity to take care of attendance responsibilities

Below is a sample agenda as it should be written on the board

AGENDA

Teacher's Name
Physical and Earth Science, Period 1
September, 1984

Objective:	To recognize factors that determine the climate of an area.
Dispatch:	Write a brief description of the place where you would like to be living ten years from now. Describe its climate including changes throughout the year.
Class Work:	Discussion of the factors which influence climate.

Independent Work: Using textbooks, classroom references and library books, locate a specific place in the world and describe its climate. Explain how the geographical factors influence its climate.

Homework: Using a daily newspaper and television reports, write a report on the national weather. Plan a long-term project to chart weather for the remainder of the school year.

Summary: Summarize factors which influence climate.

GUIDELINES FOR ASSIGNMENT OF HOMEWORK*

These guidelines should be considered when planning homework assignments:

1. Homework is an important resource for teachers in helping students to learn.
2. Homework may be scheduled when appropriate, over an extended period of time, which may include weekends.
3. Homework assignments should be reasonable in length, content, and required resources.
4. Homework should be assigned to reinforce, extend, and enrich learning.
5. Homework assignments should be related to course objectives.
6. Homework assignments and due dates should be thoroughly explained by the teacher and understood by the student.
7. Once homework has been assigned, it becomes the responsibility of the student to learn the content, process, due date, and to complete and return the assignment required.
8. Completed homework assignments should be acknowledged and/or evaluated by the teacher and reviewed with students.

Parents and guardians should be informed of homework schedules, including dates given and time allowance. They should also understand the level of independent work expected of the student and the parental help and involvement required.

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*Los Angeles Unified School District, Revised Guidelines for Assignment for Homework, Office of Instruction, Bulletin No. 22, May 5, 1981.

HOW TO USE THIS OUTLINE

This course outline includes a summary of representative objectives, a time schedule, and a sequence for each unit. The introductory section on skills and concepts is designed to be taught separately for a brief period and is also to be included throughout the course as each unit is studied. The skills and concepts in the introductory section are those which are to be developed as needed for maximum relevance to the student laboratory activities. Included are an introduction, cognitive skill measurement, quality skill building, the scientific method, careful and responsible laboratory activities, library and research skills, opportunities for students to correct misconceptions, and laboratory reports.

All ten units are divided into suggested course content areas. Each area is correlated with the skills continuum which is located in Appendix C, with the skills to be developed in this course, and with sample teacher-directed lessons. The sample lessons for all ten units are based on the Quality Skill Building (QSB) model. This model is effective because the students will find the results of the lessons to be more effective and enjoyable and the instruction more efficient.

By developing a lesson in this format, the teacher will clarify outcomes, values to students, and instructional strategy. Planning and preparation of worksheets and study guides for students are encouraged. The guides and worksheets should be designed for use in both the regular and alternative lessons and for high- or low-ability students.

In the teaching strategies section of this instructional course outline, there are a variety of suggested teaching methodologies to provide for various learning modalities.

In the evaluation section the teacher will find suggestions and descriptions of different methods of testing. By using the QSB model, the teacher can clarify objectives and expedite testing.

Tips for Parents will assist the teacher in obtaining parental support. Copies of these tips may be distributed to students to help stimulate parent involvement.

Appendix A consists of Dr. Anton E. Lawson's "Classroom Test of Formal Operations," which is reproduced with permission. The appendices also include titles of District publications and the science skills continuum. This continuum encompasses the four competency strands of attitudes, thinking processes, skills, and knowledge.

TIME SCHEDULE AND SEQUENCE OF UNITS

UNIT	TOPICS	WEEKS
Skills and concepts required and developed in Physical and Earth Science AB and integrated into all other units		1
1	Mechanics	4
2	Waves	3
3	Electricity and Magnetism	3
4	Properties of Matter	4
5	Nuclear Energy	3
6	Description of the Lithosphere	4
7	Geological Processes	3
8	The Hydrosphere	3
9	The Properties of the Atmosphere and the Processes of Weather	4
10	The Universe and Space	5

SKILLS AND CONCEPTS REQUIRED AND DEVELOPED IN PHYSICAL AND EARTH SCIENCE AB (ONE WEEK)

Representative Objectives for This Unit

- Assemble and use laboratory apparatus, tools, and materials in a skillful manner, giving due attention to safety measures.

- Develop ability to generate data by observing, recalling, recognizing, identifying, and measuring.

- Prepare a laboratory report.

- Gather information from the library and other appropriate sources.

Content

I. Introduction

Physical and Earth Science AB has been designed to help students develop concepts about the physical principles that govern our existence within the universe. The classroom has the potential to be a place of great adventure for both students and teachers. How science is taught-- i.e., the excitement that it generates within the students--will determine the extent of its impact. The majority of class members will be completing their graduation requirement in science. If scientifically literate citizens are needed, this is an important opportunity.

In the presentation of the skills that are fundamental to the understanding of physical and earth science, the teacher has an unexcelled opportunity to assist in the development of vital thinking skills and the scientific literacy required for life in the twenty-first century. Research in science education provides the teacher with the knowledge that he/she is dealing with students who are moving through a period of cognitive skill development. This transition period gradually moves from the concrete operational to the formal theoretical thought that is so critical to the understanding and utilization of science and mathematics. Creative instructional techniques can capitalize on the development of these skills. Permitting students to evaluate their misconceptions about physical principles is an effective method to move from concept exploration into concept development and, finally, concept application. In the application phase, the teacher will generally be able to determine whether or not the students are utilizing formal theoretical skills. Students do not enroll in this class or others with a lack of belief systems about physical principles. Typically, they have concrete intuitive misconceptions which, through instruction, can be overcome.

Content

II. Cognitive Skill Measurement

Dr. Anton Lawson, Department of Physics, Arizona State University, Tempe, Arizona, has developed and validated a test for teacher observation of student cognitive skill growth in science. (See Appendix A.) His test is based upon student use of data and capacity to analyze. Little information about specific subject matter content is needed. Use of this test will provide the teacher with an opportunity to measure change in students moving from concrete opertional thought to formal theoretical thought. Even a student lacking in skills will show growth during a year of experience in science. Use of this test can provide the teacher with the opportunity to practice creativity in developing "mind stretchers" for students.

Use of the formal operational thought processes opens the door for a superb development of the scientific method. This logical thought process has influenced the entire world, its thinking processes, its technologies, and its philosophy. There is almost nothing more attractive to the adolescent learner than to embark on a crusade of thinking. Let the student know where he/she is in thought process development. Students will typically move with the teacher if intrigued.

The crusade of thinking must, however, include development of literacy in science, which includes analytical writing ability. To write correctly, the student must know vocabulary and finally must be given the opportunity to write about experiences within the framework of the class. Provide the student with a good format for laboratory reports, and then assist the learner in its use. It is not sufficient to carry on a Socratic dialogue with students. Learners must be given the opportunities to write, edit, rewrite, and receive appropriate feedback from the teacher. Evaluation of verbal skill offers significant opportunities for analysis; however, the task should not be limited to the verbal presentation. The opportunities to observe require the manipulation of equipment and use of chemicals. Students must be taught observational skills.

III. Quality Skill Building

All of the material in this course outline is dependent upon the use of Quality Skill Building. All lesson plans use the District-approved format. However, involving the students in the concepts of learning through the use of Bloom's Taxonomy, the modalities of learning, and the seven steps in the lesson plan will provide the teacher with a major asset. This format permits the teacher to be central to the learning act, and it helps prepare the student concerning what to expect. The quality of interaction between the student and the teacher is primary to the acceleration of learning at any level.

There is no subject that is as all-encompassing as the variety of disciplines found in science. Investigation and hands-on activities are keystones to the learning experience in science. Even desultory students become motivated when they determine their own need to reduce a random approach to education and to develop a structured approach. Class members are able to clarify and develop realistic goals and are made aware of their participation in the learning process.

Content

IV. The Scientific Method

Below are sets of general questions that address the classical parts of the scientific method. Students should be able to answer these questions. A good place to start is the Guided-Group Practice Section of the Teacher-Directed Instructional Sequence. In this segment, it is easy to determine whether or not the students have misconceptions about physical phenomena.

A. A clear statement of the problem

- What do you believe in? (In relationship to this investigation)
- What are you looking for?
- What do you want to prove?
- What factors and variables must you include?
- What information do you need before you progress?

B. Collecting the information

- Where are you going to look?
- Are you going to use primary or secondary sources of information?
- How do you set up equipment, use the necessary chemicals, care for the specimens?

Skills Continuum

4.1.1 Distinguishes between trial and error and controlled investigations.

1.5.1 Recognizes the alternative factors to be considered when examining possible solutions.

1.6.1 Understands the need to log data he/she actually gathered.

2.1.1 Examines objects carefully, using a combination of senses to collect and process data; derives meaning from the observation; recognizes the need to use simple instruments to aid the senses in collecting data.

2.1.2 Determines the need to repeat observations as a means of improving reliability.

Content

C. Forming a hypothesis

- What must be included?
- What is the proper wording of a hypothesis?
- Do you need to consider groups or sets of information?
- Do you have some idea of the outcome?
- Do you need a control?
- Have you written the hypothesis in a complete sentence?

D. Testing the hypothesis

- Do you know how to set up equipment safely?
- If you are using chemicals, are any of them dangerous?
- What safety precautions must you use at all times in the laboratory?
- If you are working with a laboratory team, does each person know what he/she is supposed to do?
- Do you know what changes you are looking for?

E. Gathering and recording data

- Do you know how to group data in several different ways?
- Do you know how to make tables?
- Do you know how to rearrange tables in relationship to variables?

Skills Continuum

1.6.2 Forms opinions only after seeking a variety of data and ideas.

1.7.0 Has a critical, questioning attitude toward inferences, hypotheses, and theories.

Content	Continuum Skills
F. Analyzing data . How do you read graphs? . How do you move from symbols to complete sentences?	1.8.0 Applies rational and creative-thinking processes when trying to find relationships among seemingly unrelated phenomena and when seeking solutions to problems. 2.3.0 Develops ability to apply and evaluate data and generate theories by hypothesizing, predicting, inferring, generalizing, theorizing, explaining, justifying, judging, and interpreting.
G. Reaching the conclusion . Do you have the ability to write sequentially, logically? . Does what you write reflect the data that you have collected? . What other variables must you discuss in your conclusion? . Have your conclusions and observations changed your belief about these events?	1.6.0 Organizes and reports the results of scientific investigations in an honest and objective manner. 1.6.3 Assumes responsibility for reporting results in an honest and objective manner. 1.8.2 Applies problem-solving techniques of science in everyday-life-situations. 4.1.3 Evaluates procedures in the inquiry process that have been omitted or inadequately performed.

V. Responsible Laboratory Activities

The smallest experimental detail that is carefully observed often makes the difference between correlating information correctly or incorrectly. Prepare the students for the laboratory. Explain the problems, review equipment set-up, go over the use of chemicals, emphasize safety and cleanliness, and try to anticipate the errors before they occur.

Point out that the essence of science is to work out (often in microworlds) the hypothesis upon which many other technologies and discoveries may develop. An important point to make is that many of the classical experiments in physical and earth science are done in the laboratory and not in the field.

A. Safety is a necessary requirement.

Ask your students the following:

- Do you know how to handle dangerous chemicals, fires, electrical circuits, gas, chemical spillage, and clean-up?
- Do you know that broken glass is treacherous?
- Do you know how to eliminate danger in the lab without eliminating excitement?
- What is the appropriate first aid in any of the above situations?

Content

B. The data collected must be accurate, both quantitatively and qualitatively.

Ask your students the following:

- Do you know what changes are to be observed - e.g., precipitate, color, amount, vapor, size, shape, texture of specimens, and other identifying marks?
- What is qualitative change versus quantitative change?

Qualitative change is easier to handle in the lab than is quantitative change. However, once the student crosses the the number manipulation barrier, the teacher may well be able to handle quantitative experiments.

Continuum Skills

2.1.1 Examines objects carefully, using a combination of senses to collect and process data; derives meaning from the observation; recognizes the need to use simple instruments to aid the senses in collecting data.

2.1.2 Determines the need to repeat observations as a means of improving reliability.

2.1.3 Uses measurement procedures to improve accuracy of observations.

2.1.4 Identifies changes in properties and rates of change.

3.1.1 Manipulates simple materials, apparatus, and equipment in a safe manner.

3.5.2 Tabulates information and uses tables.

3.7.0 Uses the metric system effectively.

3.7.1 Counts, uses numbers, and balances objects on an equal-arm balance scale.

3.7.2 Measures linear distances, using a metric ruler.

3.7.3 Uses a balance to determine the mass of objects.

3.7.4 Measures volume of liquids in a graduated cylinder marked in metric units.

Content	Continuum Skills
C. Acceptance or rejection of the hypothesis is based upon data analysis. 1. Use a null hypothesis on occasion. 2. Instruct students to make a comparison based upon use of the null hypothesis.	
D. Results of experiments must be recorded and communicated. Each student is a scientist, albeit a beginning one. He/she can think in formal patterns. An exemplary method for developing and communicating results of any experiment is to have students prepare for and present the results of experiments in the format of a scientific meeting. Papers are written and then presented orally. This approach will work well only if there is enough variety in the experiments and a diversity of variables. Look for the use of the simple, short declarative sentence. Students can make use of this type of sentence most effectively in writing descriptions of results. Speaking, listening, reading, and writing are all language skills that must be emphasized in this segment. Of the language skills, writing is the most analytical, for it provides graphic representation of mind processes.	3.6.0 Communicates with others in a manner that is consistent with knowledge. 3.6.2 Explains, either orally or in writing, the methods and procedures involved in carrying out an investigation.
E. Appropriate mathematical concepts must be used, including that of the metric system. Most students associate arithmetic functions with mathematics. By encouraging them to function at the qualitative level in initial concept exploration, they are generally more willing to deal with mathematical concepts. In this course, these would relate to measurement, ratio, proportion, and percentages.	3.5.3 Interprets graphs and displays data graphically. 3.7.0 Uses the metric system effectively. 3.8.0 Applies appropriate mathematical concepts and skills in interpreting data and in solving problems. 3.8.1 Calculates rates from data.

Content	Continuum Skills
The following concepts can be reinforced: measurement in both metric and English systems; units of volume; length; mass; temperature; percentage error; ratio and proportion; graphing; and other visual display methods that are based upon mathematics.	
F. Analysis of data must be consistent with conclusions.	4.2.0 Demonstrates understanding of basic generalizations, relationships, and principles.
Here the teacher and the student are dealing with the thinking processes that permit correlation of observation with known physical principles. Remember that error is going to occur. The student must always be placed in the position of having to deal with real belief systems and to examine the information in relationship with the known values.	
Often the teacher can only determine the source of error by talking with the students. The errors may not always relate to arithmetic, but may in fact be intuitive. The teacher can set an admirable model by using the simple words: "I don't know." These words are the essence of science when followed by: "Let's find out!"	
VI. Library and Research Skills to Investigate Topics of Scientific Interest	1.5.2 Examines a variety of alternative viewpoints on scientific issues to form opinions about them.
A. The librarian, as a resource person, assists the teacher in selecting appropriate reading material for students.	1.8.2 Applies science problem-solving techniques in everyday-life situations.

Content	Continuum Skills
B. All of the old familiar resource materials are still effective tools, and they help students to reinforce knowledge and skills learned in other classes.	
C. Recent scientific journals, periodicals, newspapers and science fiction should be available. Often the work of outstanding science fiction writers, such as Madeleine L'Engle, will cause students to pursue a topic with great interest.	3.4.0 Gathers needed information which has been generated by others from a variety of sources appropriate to his/her ability level. 3.4.1 Listens to the ideas of others. 3.4.2 Gathers information from science textbooks, reference materials, films, and television. 3.4.3 Finds sources of information needed to solve a problem related to a specific topic.
D. Expert opinion is a research tool. The teacher has the ability to inspire students. Trite as it may sound, the teacher is the student's mentor. Questions are frequently asked that require more information than is available. If possible, the teacher should maintain a small resource library. Dictionaries, science encyclopedias, and the Time-Life books are among the resources which should be available.	

Content | Continuum Skills

VII. Providing Opportunities for Students to Correct Misconceptions

Learning about science is a "hands-on" experience that utilizes formal thought processes. Too frequently, however, instruction in science is separated from learning in other fields. Basic skills learned in other fields must be integrated with instruction in science.

Physical and Earth Science AB provides an admirable opportunity for introduction of information about minorities, women, and handicapped individuals who have overcome barriers to succeed in science.

Students do not walk into class with a blank mind about physical phenomena. Most of them have already dealt with the need to resolve questions about physical events, generally incorrectly. The teacher's task is to correct these misconceptions and to help students develop scientific literacy.

LABORATORY REPORT

The following are suggested steps that should be included in the preparation of a typical laboratory report. Teachers are encouraged to adapt this form to meet the individual needs of the students.

I. TITLE

Example: The Compound Microscope

II. PURPOSE OR STATEMENT OF THE PROBLEM

Example: The purpose of this investigation is to observe and record specific data about various organisms.

III. HYPOTHESIS

A statement of a hypothesis is useful for experimental investigations. Example: Light is not a factor involved in plant growth.

IV. MATERIALS

V. PROCEDURE

A step-by-step list of the procedures used in the investigation.

VI. DATA

Written and/or graphic.

VII. ANALYSIS OF RESULTS

Any mathematical treatments need to be described in detail.

VIII. CONCLUSIONS

The conclusions include several considerations:

A. Was the hypothesis supported or rejected?
B. The investigator's opinion concerning the data and results.
C. Limitations.
D. Suggestions for further investigation.

Representative Objectives for This Unit

- Distinguish between the kinematic variables: speed, velocity, acceleration, distance and displacement.
- Be able to predict the changes in motions of objects using Newton's three laws of motion.
- Be able to distinguish and give examples of kinetic and potential energy.
- Be able to define and differentiate between work, force, and power.
- Describe and predict the functions of simple machines as illustrations of Newtonian Mechanics.
- Relate the consistency of a physical event with a physical law.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.
- Identify and describe careers at various levels in the physical sciences.

Content

I. Important kinematic variables must be considered.

   A. Speed is the rate at which the position of a body changes with respect to time.

Continuum Skills

2.1.0 Develops ability to generate data by observing, recalling, recognizing, identifying, and measuring.

2.1.4 Identifies changes in properties and rates of change.

4.2.2 Uses a cause-effect relationship to make a prediction.

4.4.10 Identifies pairs of objects having similar properties.

4.8.0 Demonstrates general knowledge of science.

Content	Continuum Skills
B. Displacement is a change of position in a particular direction.	3.5.3 Interprets graphs and displays data graphically.
C. Acceleration is the rate of change of velocity.	
D. Velocity is speed in a particular direction.	
II. Students will compare vector and scalar quantities.	1.8.1 Attempts spontaneously to describe an object or event that has attracted his/her attention.
A. Scalar quantities have magnitude only.	4.8.0 Demonstrates general knowledge of science.
B. Vector quantities have both magnitude and direction.	
C. Vector quantities can be represented by line segments with arrowheads to show direction.	
D. Vectors can be added by a tip to tail graphical method.	
III. Newton's laws of motion govern interactions between objects.	4.2.1 Identifies simple cause and effect relationships.
A. If no net force acts on a body, the body will continue in its state of rest or will continue moving in a straight line at constant speed.	4.5.1 Matches significant discoveries to persons responsible.
B. A net force, not zero, applied to an object will cause the object to accelerate in the direction of the force. The acceleration is in direct proportion to the force and in inverse proportion to the mass of the object.	

Content	Continuum Skills
C. When one object exerts a force on a second object, the second object exerts on the first a force of equal magnitude in the opposite direction.	
IV. Newton's law of universal gravitation affects all bodies.	1.1.1 Shows willingness to examine and organize objects and events in the environment.
A. The gravitational force between two bodies is proportinal to the product of the masses of the bodies and inversely proportional to the distance between their centers of mass.	4.8.0 Demonstrates general knowledge of science. 4.8.13 Recognizes that the motion and path of celestial bodies are predictable.
B. Gravitational force is the centripetal force which causes satellites to revolve around planets.	
V. Energy is the capacity to do work.	4.2.9 Identifies examples of kinetic and potential energy.
A. Objects in motion possess kinetic energy.	4.8.30 Understands the definitions and interrelationships of force, work, and energy.
B. Potential energy is energy resulting from position.	
VI. Work is the product of a displacement and the force in the direction of the displacement.	
VII. Power is the rate at which work is done.	3.8.1 Calculates rates from data.
VIII. Machines are devices that decrease the force needed to do work by either increasing the distance through which the force acts or the reverse.	1.1.0 Shows curiosity about objects and events. (See Sample Lesson: Machines and Their Advantages: Mechanics.)

Content

A. In order to appreciate the features of machines, it is necessary to understand the concepts of force and work.

   1. A force is a push or a pull.

   2. Work equals force multiplied by distance.

B. Machines allow humans to increase work capacity by changing the direction, size, or distance through which a force moves.

   1. There are six simple machines:

      a. Lever
      b. Pulley
      c. Inclined plane
      d. Wedge
      e. Screw
      f. Wheel and axle

   2. Compound machines are two or more simple machines working together.

   3. The mechancial advantage is the amount by which a machine multiplies the force being applied.

   4. Efficiency is the ratio of the work output to the work input.

   5. Power is work divided by time.

Continuum Skills

4.8.29 Recognizes simple machines and their functions.
(Skills Unit V): Responsible laboratory activities

(Skills Unit V B): Accurate data collection, both quantitatively and qualitatively.

Content	Continuum Skills
IX. Students will find that there are various careers related to mechanics.	
A. Machinist	1.10.1 Values the abilities, interests, and preparation required to seek employment in a science-related career.
B. Tool and diemaker	
C. Mechanic	
D. Carpenter	
E. Sheetmetal worker	
F. Pattern maker	
G. Auto worker	

UNIT TWO: WAVES

Representative Objectives for This Unit

- Describe the properties of waves.
- Differentiate between reflection and refraction.
- Compare the refraction of light by two different types of lenses.
- Relate the properties of light and sound to the processes of seeing and hearing.
- Relate the consistency of a physical event with a physical law.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.
- Identify and describe careers at various levels in the physical sciences.

Content

I. A wave is a way of transporting energy through a medium or through space.

   A. A transverse wave consists of crests and troughs.

   B. A longitudinal or sound wave consists of compressions and rarefactions.

   C. The distance between adjacent crests or adjacent troughs is a wavelength.

   D. The amplitude is the maximum displacement of the wave from its rest or equilibrium position.

   E. The frequency of a wave is the number of waves that pass through a given point per unit of time.

   F. The inverse of the frequency is called the period.

Continuum Skills

1.1.0 Shows curiosity about objects and events.

4.2.1 Identifies simple cause and effect relationships

4.8.0 Demonstrates general knowledge of science.
(See Sample Lesson: Optics.)

(Skills Unit V): Responsible laboratory activities

Content	Continuum Skills
II. Sound waves are compression waves produced by vibrations through a medium. Sound cannot travel through a vacuum.	
A. A wavelength is the distance between adjacent compressions or adjacent refactions.	
B. Sound waves can be reflected (echoed) or refracted (bent).	
C. The three physical properties of sound are intensity, frequency, and harmonic content.	
1. The effect of intensity on the ear is called loudness. 2. The effect of frequency on the ear is called pitch. 3. The effect of harmonic content on the ear is called quality.	3.6.1 In group settings, orally describes observations and answers questions. (Skills Unit IV B): Collecting the information.
D. Interference can be either constructive or destructive.	
E. The Doppler Effect is a change in wave frequency caused by the motion of the source of the wave toward or away from the observer.	
III. Optics is the study of the nature and properties of light.	1.1.0 Shows curiosity about objects and events.
A. Light waves are transverse waves which travel fastest through a vacuum.	3.3.1 Makes purposeful, objective observations. (Skills Unit V F): Analysis of data must be consistent with conclusions.

Content	Continuum Skills
B. Light consists of quanta or photons, which are discrete bundles of energy.	4.2.1 Identifies simple cause and effect relationships.
C. Light exhibits reflection, refraction, diffraction, interference, dispersion, polarization, and the Doppler Effect.	4.8.0 Demonstrates general knowledge of science. 3.6.1 In group settings, orally describes observations and answers questions.
D. Light produces real and virtual images, depending on the mirrors or lenses used to observe the images.	(Skills Unit V B): Data is collected accurately, both quantitatively and qualitatively.
E. Convex lenses produce real, virtual, enlarged or reduced images depending on the position of the object relative to the focal length of the lens.	
F. Concave lenses produce an image that is diminished and virtual.	
G. Lenses may be used to correct vision.	
H. Lenses are used in instruments, such as telescopes, microscopes, and cameras.	
I. Prisms and diffraction gratings are used to disperse light into its component colors.	
J. Lasers are high-intensity coherent light sources that have many technological applications.	
IV. Many laboratory activities are related to the observation and measurement of waves. (See Section on Machines.)	2.1.3 Uses measurement procedures to improve accuracy of observations.

Content	Continuum Skills
V. Students will find that there are many careers related to work with instruments which produce waves or use waves for observation and measurements. A. Optician B. Ultrasound technician C. Sonar technician D. Electron microscope technician	1.10.1 Values the abilities, interests, and preparation required for a science-related career.

UNIT THREE: ELECTRICITY AND MAGNETISM

Representative Objectives for This Unit

- Describe the proton, neutron, and electron model for the atom.
- Relate static electricity to the model of the atom.
- Formulate relationships between current flow in a circuit with the atomic model.
- Define and measure at least three electrical units; e.g., ampere, ohm, and volt.
- Compare and contrast alternating and direct currents.
- Describe several magnetic effects.
- Relate the properties of magnetism to charges in motion.
- Relate the consistency of a physical event with a physical law.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.
- Identify and describe careers at various levels in the physical sciences.

Content	Continuum Skills
I. Energy is the ability to do work. Electricity is a fundamental type of energy that is manifested in the form of negatively charged electrons that are present in atoms.	1.4.0 Takes an active role in solving social problems related to science and technology. (Skills Unit VII): Providing students with the opportunity to correct misconceptions. 4.3.0 Demonstrates knowledge of relationships between science and society.

Content	Continuum Skills
A. The atoms are composed of positively charged protons, negatively charged electrons, and neutrons that have no charge.	1.8.0 Applies rational and creative thinking processes when trying to find relationships among seemingly unrelated phenomena and when seeking solutions to problems. 4.2.3 Recognizes that atoms are composed of electrons, protons, neutrons, and other particles. 4.2.4 Recognizes that electrons are negatively charged and protons are postively charged.
B. There are negative and positive charges. 1. Like charges repel each other. 2. Unlike charges attract each other. 3. If an object gains electrons, there are more electrons than protons, so that the object is negatively charged. 4. If an object loses electrons, there are fewer electrons than protons, so that the object is positively charged.	2.1.1 Examines objects carefully, using a combination of senses to collect and process data; derives meaning from the observations, recognizes the need to use simple instruments to aid the senses in collecting data. (Skills Unit IV B): Collecting information from laboratory investigations. 2.1.3 Uses measurement procedures to improve accuracy of observations.
C. Electrically charged objects have static electricity; i.e., electricity at rest.	2.1.4 Identifies changes in properties and rates of changes.
D. Conduction of electricity occurs when electrons are gained or lost through direct contact with a charged object.	3.1.0 Assembles and uses laboratory materials in a skillful manner, giving due attention to safety measures. (Skills Unit V A): Safety is a necessary requirement.
E. Electrostatic induction occurs when electrons repel each other.	3.5.0 Records observations accurately and organizes data and ideas in ways that improve their usefulness. (Skills Unit V B): Accurate data collection is conducted both quantitatively and qualitatively.

Content	Continuum Skills
F. Grounding an object to the earth with a conductor allows electrons to move freely in and out of the object.	4.1.0 Demonstrates knowledge of the processes of scientific inquiry.
G. Direct current (D.C.) is the flow of electrons through a conductor.	
H. Alternating current (A.C.) is the back and forth movement of electrons in a circuit or conductor.	4.2.0 Demonstrates understanding of basic generalizations, relationships, and principles. (See Sample Lesson: Circuits.)
I. Electrical measurement devices measure the flow of electrons through objects. 1. An ammeter measures currents in amperes. (An ampere is the rate of electron flow in a circuit.) 2. A voltmeter measures the electromotive force in volts. 3. An ohmmeter measures the resistance of a circuit component.	
II. Today, it is believed that all magnetic phenomena result from forces between electric charges in motion.	
A. Magnetism is a property of matter.	4.8.0 Demonstrates a general knowledge of science. (Skills Unit VII): Providing students with the opportunity to correct misconceptions.
B. Magnetism can produce electricity, and electricity can produce magnetism.	
C. Magnets are usually made of steel, cobalt, or nickel. These metals can become induced to become magnets themselves by an electric current.	
D. A magnet can cause electric current in conductors.	

E. Magnets have two unlike poles--north and south.

   1. Like poles of magnets repel each other.
   2. Unlike poles of magnets attract each other.

F. Lines of force forming a magnetic field surround a magnet.

III. Electronic devices are important in society today.

A. An electric circuit is a pathway through which a current flows.

B. There are two basic types of circuits, series and parallel.

C. Amplification of voltage to be used in radios, televisions, etc. are gastight containers called vacuum tubes.

D. Transistors have replaced vacuum tubes since they are much smaller, last longer, and consume less energy.

E. Integrated circuits are very small electronic devices capable of doing many complex jobs. They are long-lasting, reliable, and are made in chips of silicon crystals.

F. Complex machines called electronic computers contain electric circuits, vacuum tubes, transistors, integrated circuits, and electromagnets.

Content	Continuum Skills
IV. Students will find that many career opportunities are related to electricity and electronics.	
A. Electronic technicians	1.10.1 Values the abilities, interests, and preparation required for a science-related career.
B. Electricians	
C. Computer technicians	

Representative Objectives for This Unit

- Describe concepts involved in matter and its changes.
- Describe models of atoms.
- Relate the consistency of a physical event with a physical law.
- Distinguish between an element, a compound, and a mixture.
- Interpret the Periodic Table.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.
- Identify and describe careers at various levels in the physical sciences.

Content

I. Physical science is the study of matter and energy.

   A. Chemistry is the study of what matter is made of and the changes in matter.

   B. Physics is the study of how matter and energy are related.

II. Matter is anything that has mass and takes up space.

   A. Mass is the amount of material a body contains.

   B. Atoms are the smallest units of elemental matter.

Continuum Skills

4.1.0 Demonstrates knowledge of the processes of scientific inquiry. (Skills Unit V B): Accurate data collection is conducted both quantitatively and qualitatively.

4.2.0 Demonstrates understanding of basic generalizations, relationships, and principles.

CONTENT	Continuum Skills
C. Atoms are composed of subatomic particles called protons, neutrons, and electrons.	4.2.3 Recognizes that atoms are composed of electrons, protons, neutrons, and other particles. 4.2.6 Recognizes that matter is composed of particles which are in constant motion. 4.2.7 Describes interaction and reorganization of units of matter and their association with changes of energy.
1. The nucleus consists of positively charged protons and neutrons that carry no charge.	
2. The negatively charged electrons are located outside the nucleus.	
3. The atomic number is equal to the number of protons or the number of electrons in an electrically neutral atom.	4.2.5 Illustrates that the number of atomic particles varies with each element. 4.8.0 Demonstrates general knowledge of science.
4. The atomic mass is approximately equal to the number of protons and neutrons.	
5. The Bohr model of atoms depicts the electrons in "planetary orbits" around the nucleus.	
6. The electron cloud model of atoms describes the electron as contributing to a charged cloud around the nucleus.	
D. The number of atomic particles varies with each element.	
E. Matter, in its common state, exists as solid, liquid, or gas.	4.8.19 Recognizes that matter exists as solids, liquids, and gases.

Content

F. The amount of matter remains the same during chemical or physical changes.

   1. When matter undergoes physical change, only its size, shape, or form changes and no new substances are produced.
   2. When matter undergoes chemical change, new substances with new properties appear.

III. Matter is classified according to its physical and chemical properties.

A. An element is a pure substance consisting of only one kind of atom.

   1. Elements differ from each other by their structures.
   2. Elements can be identified by one or two-letter symbols.

B. A compound is made of a combination of elements.

   1. Formulas are used to represent compounds.
   2. Elements in a given compound are always combined in the same ratios and lose their characteristic elemental properties.
   3. There are many kinds of compounds, but all have properties which are different from the atoms which formed them.
   4. Ionic compounds can be classified as an acid, a base, or neutral.

      a. Acids have an excess of hydrogen ions.
      b. Bases have an excess of hydroxide ions.
      c. A neutral solution has an equal amount of hydrogen ions and hydroxide ions.

Continuum Skills

(See Sample Lesson: Elements, Compounds, and Mixtures.)

Content

C. Mixtures consist of two or more pure substances that are mixed together without combining chemically.

   1. Mixtures can be separated by physical means.
   2. A mixture may or may not have the same composition throughout.

D. Solutions are special kinds of mixtures in which one substance is dissolved in another.

   1. The solute is the substance that has been dissolved.
   2. The solvent is the substance in which the solute has been dissolved.
   3. The strength of a solution is referred to as its concentration.
   4. Depending on the environmental conditions (primarily the temperature), the amount of solute dissolved in solvent may vary.

E. The Periodic Table is related to the properties of elements.

   1. Elements are arranged in the sequence of increasing atomic numbers. In general, the atomic weights of the elements increase as their atomic numbers increase. There are three exceptions among the common elements, potassium, nickel, and iodine.
   2. Elements are also arranged by groups in vertical columns. The vertical columns are divided into two groups: the A group and the B group.

Continuum Skills

4.8.0 Demonstrates general knowledge of science.

3. Elements in the same group have similar chemical properties. The chemical behavior of an atom is determined primarily by its size and the number of electrons in the outermost shell. The elements in the same A group have the same number of electrons in the outermost shell and therefore possess similar properties.
4. Elements are also grouped in horizontal rows or periods. Each row begins with metallic elements and ends with nonmetallic elements.

   a. Those elements on the far left are highly active metals.
   b. Those elements on the far right, in group VIII, are very inactive nonmetals. Those elements in group VII A and at the top of groups V A and VI A are active nonmetals.
   c. A-group elements found in the same horizontal row do not have similar properties. B-group elements in the same horizontal rows have similar properties.

5. Information usually given in each of the boxes of the Periodic Table include:

   a. Atomic number
   b. Symbol for the element
   c. Average atomic mass
   d. Number of electrons in each shell

Content	Continuum Skills
6. Some special families in the Periodic Table are: a. Inert or noble gases b. Alkali metals c. Halogens	
IV. Students will find that many career opportunities are in fields that use chemicals or in which chemicals are identified.	4.4.0 Demonstrates knowledge of science-related career opportunities and the preparation needed.
A. Assayer	
B. Chemical lab technician	
C. Potter	
D. Hydroponics technician	
E. Pest controller	
F. Medical research technician	

UNIT FIVE: NUCLEAR ENERGY

Representative Objectives for This Unit

- Recognize the history of nuclear energy.
- Describe the concepts involved in matter and its changes.
- Relate the consistency of a physical event with a physical law.
- Describe the properties of radiation.
- Distinguish between nuclear fission, fusion, and breeder reactors.
- Assess the political, military, and health issues of the nuclear age.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.
- Identify and describe careers at various levels in the physical sciences.

Content	Continuum Skills
I. Scientists have made important discoveries in the field of nuclear energy during the past 100 years.	
A. Major contributions of scientists	1.9.3 Values the scientific contributions of human beings from varying cultural backgrounds. (Skills Unit VII): Providing students with the opportunity to correct misconceptions.
1. Becquerel--Discovered radiation from uranium. 2. The Curies--Isolated radium and polonium. 3. Roentgen--Discovered X-rays. 4. Thompson--Demonstrated existence of the electron. 5. Rutherford--Discovered the atomic nucleus. 6. Millikan--Measured the charge on an electron.	4.5.1 Matches significant discoveries to persons responsible.

Content	Continuum Skills
7. Einstein--Formulated the theory of relativity and the equivalence of mass and energy, $E = mc^2$.	
8. Fermi--Directed the Manhattan Project at the University of Chicago.	
9. Oppenheimer--Participated in the Los Alamos Project in New Mexico.	
10. Bohr--Contributed to atomic theory, nuclear reactions, and nuclear fission.	
B. Manhattan Project	
C. Los Alamos Project	
D. Political climate during World War II	
E. Atom Bombs dropped at Hiroshima and Nagasaki	
II. The sources and properties of radiation.	
A. X-rays are high energy radiation which can be produced by machines or natural events.	4.8.0 Demonstrates general knowledge of science.
1. Part of the electromagnetic spectrum.	
2. Has short wavelengths.	
3. Produced by electrons striking metal.	
4. Not deflected by electric charges or magnetic fields.	
5. Roentgen: standard unit to measure X-rays.	
B. Radioactivity is high energy radiation emitted from certain atoms.	4.2.3 Recognizes that atoms are composed of electrons, protons, neutrons, and other particles.

CONTENT

1. Becquerel discovered radioactivity in uranium ore.
2. The Curies isolated the radioactive elements radium and polonium.
3. Radioactivity usually occurs in atoms with atomic masses greater than 206.
4. Radioactive isotopes have different numbers of neutrons.
5. Radioactive elements can transmutate from one element to another, releasing radiation.

   a. Alpha particles--Helium nuclei
   b. Beta particles--Electrons
   c. Gamma rays--Short wavelength and high frequency electromagnetic radiation

6. Half-life is the time it takes for half of the atoms in a radioactive material to decay to other kinds of atoms.
7. Detection of radiation can be done through electroscopes, cloud and bubble chambers, film emulsions, and geiger counters.

III. Nuclear reactors and reactions produce high energy particles.

A. A cyclotron is a device used to accelerate charged particles to very high speeds for the purpose of causing nuclear reactions.

B. Nuclear forces bind protons and neutrons together.

Continuum Skills

4.2.4 Recognizes that electrons are negatively charged and protons are positively charged.

4.2.5 Illustrates that the number of atomic particles varies with each element.

(See Sample Lesson: Radiation.)

Content	Continuum Skills
C. The atomic nucleus can undergo three kinds of nuclear change. 1. Transmutation--One element changes to another by a change in the number of protons. 2. Fission--A large nucleus is divided, resulting in the release of nuclear energy. 3. Fusion--Two or more small atomic nuclei unite to form a single heavier nucleus, freeing energy. a. This process takes a tremendously high temperature to occur. b. Matter becomes plasma. c. Fusion is called a thermonuclear reaction. d. Fusion occurs in stars.	4.2.7 Describes interaction and reorganization of units of matter and their association with changes of energy. (Skills Unit IV): The scientific method 4.8.21 Recognizes that in nuclear reactions a loss of matter is a gain in energy; the sum of matter and energy remains constant.
D. Nuclear reactors produce nuclear energy by fission. 1. Advantages of nuclear reactors a. Less air pollution. b. More energy from smaller amounts of fuel. c. Alternate energy source. 2. Disadvantages of nuclear reactors a. Thermopollution caused by the vast amount of water needed to cool the reactors. b. The need for proper disposal of radioactive wastes. c. Possibility of a core meltdown, resulting in contamination of the air by radiation. d. Possibility of other nuclear accidents.	4.2.8 Recognizes the uses of fuels.

CONTENT

IV. What are some of the sociological and political ramifications of the nuclear age?

A. The public health issues

1. Protection from radiation
2. Diagnosis and treatment of diseases

B. Political and military issues

1. SALT talks--USSR vs. USA
2. Other countries with nuclear energy capacities

C. Sociological issues

1. International Union of Physicists
2. Environmental Protection Agency

Continuum Skills

(Skills Unit VII): Providing students with the opportunity to correct misconceptions.

1.5.1 Recognizes the alternative factors to be considered when examining possible solutions.

3.4.1 Listens to ideas of others.

4.3.1 Gives examples of ways in which the use of scientific knowledge has affected society.

1.4.0 Takes an active role in solving social problems related to science and technology.

1.4.2 Develops and expresses an opinion on a social issue.

1.4.3 Seeks to influence the views and behaviors of others with respect to social issues related to science technology.

2.3.1 Examines environmental issues, pointing out contradictions and discrepancies in the positions of various groups.

CONTENT

V. Students will find that many career opportunities involve finding and processing nuclear materials, using the products of nuclear technology, and using machines which demonstrate the principles of radiation.

- A. Nuclear technician
- B. X-ray technician
- C. Medical radiation technician
- D. Biology technician
- E. Dental technician
- F. Miner
- H. Electron microscope technician

Continuum Skills

1.10.1 Values the abilities, interests, and preparation required for a science-related career.

(Skills Unit VII): Providing students with the opportunity to correct misconceptions.

UNIT SIX: DESCRIPTION OF THE LITHOSPHERE

Representative Objectives for This Unit

- Describe the layers of the lithosphere.
- Distinguish between the three different rock forms: igneous, sedimentary, and metamorphic.
- Utilize simple tests to identify various minerals.
- Identify and relate certain fossils with the age of the earth.
- List several uses for minerals.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.
- Identify and describe careers available in the geological sciences.

Content

I. The earth's lithosphere is made of four layers: the crust, the mantle, the outer core, and the inner core.

   A. The thin crust, the outermost layer on which people live, is at its thinnest under the ocean and thickest under the mountains.

   B. Knowledge of the structure and composition of the inner layers of the earth must be obtained through observations of seismic waves.

Continuum Skills

3.4.2 Gathers information from science textbooks, reference materials, films and television.
(Skills Unit VI): Library and research skills necessary to investigate topics of scientific interest.

4.8.0 Demonstrates general knowledge of science.

Content	Continuum Skills
II. The crust is made of three types of rocks: igneous, sedimentary, and metamorphic. A. Igneous rocks are formed when molten rock called magma cools either below or above the earth's crust. 1. Igneous rocks cooled slowly below the earth's surface have large crystals and are called intrusive rocks. a. Granite, a light colored intrusive rock, is composed mostly of the minerals quartz, feldspar, and mica. b. Gabbro, a dark-colored intrusive rock, is composed mostly of the minerals which contain a great deal of iron and magnesium (pyroxenes). 2. Igneous rocks cooled quickly above the earth's surface have small or no crystals and are called extrusive rocks. a. Basalt, a dark colored extrusive rock, contains pyroxene and olivine. b. Rhyolite is a fine-grain extrusive which contains feldspar and quartz.	3.3.1 Makes purposeful, objective observations. 3.3.2 Determines the timing of a series of events. 4.6.1 Identifies how modern techniques of determining the age of specimens contribute to knowledge of earlier civilizations. 4.8.0 Demonstrates general knowledge of science. 4.8.12 Recognizes that living organisms have changed over the ages and that some species are now extinct. 4.8.24 Recognizes the three types of rocks that make up the earth.
B. Sedimentary rocks form when sediments settle to the bottom of bodies of water and are cemented together to form solid rock.	3.7.0 Uses the metric system effectively. 3.7.1 Counts, uses numbers, and balances objects on an equal-arm balance scale.

Content

1. Sedimentary rocks are classified by the type of sediments that make up that rock.

   a. Sandstone, shale, and conglomerate are examples of sedimentary rocks made from fragments of rocks.
   b. Coal and some forms of limestone are examples of sedimentary rocks made from organic sediments.
   c. Salt rock (halite), gypsum, and some forms of limestone are formed from chemical sediments.

2. Sedimentary rock can contain fossils which give a record of past life preserved in the earth's crust.

C. Metamporphic rocks are formed when either igneous or sedimentary rocks undergo extreme heat or pressure.

1. An example of a metamorphic rock formed by heat is the changing of limestone to marble.

2. Examples of a metamorphic rock formed by pressure is the changing of sandstone to quartzite, granite to gneiss, and shale to slate or to schist.

D. The process through which rocks change from one type to another is called the rock cycle.

Continuum Skills

3.7.2 Measures linear distances, using a metric ruler.

3.7.3 Uses a balance to determine the mass of objects.

3.7.4 Measures volume of liquids in a graduated cyclinder marked in metric units.

(See Sample Lesson: Minerals.)

(Skills Unit V B): Accurate data collection is conducted both quantitatively and qualitatively.

2.1.0 Develops ability to generate data by observing, recalling, recognizing, identifying, and measuring.
(Skills Unit IV): The scientific method

2.1.1 Examines objects carefully, using a combination of senses, to collect and process data; derives meaning from the observation; recognizes the need to use simple instruments to aid the senses in collecting data.

2.1.3 Uses measurement procedures to improve accuracy of observations.
(Skills Unit V): Responsible laboratory activities

Content	Continuum Skills
III. Rocks are made up of one or more minerals. Minerals are naturally-occurring inorganic elements or compounds.	2.2.1 Perceives similarities and differences in a set of objects; separates a set into groups according to a single characteristic. (Skills Unit IV): The scientific method
A. Minerals can be identified by their characteristics such as color, luster, hardness, cleavage, magnetism, streak, crystaline shape, specific gravity, and chemical reactions.	3.1.0 Assembles and uses laboratory apparatus, tools, and materials in a skillful manner, giving due attention to safety measures.
B. Many minerals are of economic importance. For example:	3.1.1 Manipulates simple materials, apparatus, and equipment.
1. Bauxite, hematite, pyrite, and galena are all ores from which metals are removed. 2. Diamonds, rubies, emeralds, and topaz are rare minerals called gems.	4.8.23 Recognizes that rocks contain one or more kinds of minerals.
C. Minerals are a "nonrenewable" resource that must be conserved through careful use.	4.8.25 Recognizes the value of using renewable energy sources instead of non-renewable sources.

Content

IV. Many careers are available in the geological sciences.

  A. Building inspector

  B. Technical secretary

  C. Drafting technician

  D. Seismic observer

  E. Miner

  F. Petrologist

  G. Heavy-equipment operator

  H. Refinery operator

  I. Seismologist

  J. Cartographer

  K. Geographer

  L. Civil engineering technician

  M. Construction inspector

Continuum Skills

1.10.1 Considers science-related careers and makes realistic decisions about preparing for such careers, taking into account abilities, interests, and preparation required.

1.10.1 Values the abilities, interests, and preparation required for a science-related career.

4.4.0 Demonstrates knowledge of science-related career opportunities and the preparation needed.

UNIT SEVEN: GEOLOGICAL PROCESSES

Representative Objectives for This Unit

- Distinguish between the processes of erosion, weathering, and deposition.
- Recognize that earthquakes can occur in populated areas and can cause extensive damage to life and property.
- Analyze the relationship between the locations of earthquakes and volcanoes.
- Describe in terms of continental drift, plate tectonics, and sea-floor spreading, the geological forces acting on the earth.
- Accept responsibility for the safe and careful handling of laboratory material and equipment.
- Identify and describe careers related to the geological sciences.

Content

I. The processes of erosion, weathering, and deposition are constantly wearing down and moving the surface of the land from a higher elevation to a lower one.

    A. Weathering is the breaking down of materials at the site in which they naturally occur. (Types of weathering: chemical & mechanical)

    B. Erosion is the process of breaking down rocks and carrying them to another place.

        1. Erosion can be caused by water, wind, and ice.
        2. The greatest amount of erosion is caused by running water which creates such landforms as "V" shaped valleys, meanders, and peneplains.

Continuum Skills

3.4.2 Gathers information from science textbooks, reference materials, science films, and television.
(Skills Unit VI): Library and research skills necessary to investigate topics of scientific interest.

4.8.22 Recognizes that there are continuous changes on earth.

Content

3. Glaciers form such erosional features as "U" shaped valleys, hanging valley falls, and cirques.

C. Deposition is the process by which sediments are laid down in a new location.

1. Deposition by running water forms such landforms as oxbow-lakes, deltas, and floodplains.
2. Deposition by glaciers forms such landforms as moraines, drumlins, and outwashplains.
3. Deposition by waves create such landforms as beaches, sandbars, and spits.
4. Deposition by wind forms such landforms as dunes and loess.

II. An earthquake is a sudden movement or shaking of the earth's crust.

A. Earthquakes occur along faults when the elastic limits of the rock are exceeded.

1. Faults are most likely to be found on the edge of continents.
2. The focus is the location on the fault where the earthquake occurred.
3. The epicenter is the location on the surface of the earth where the earthquake took place.

Continuum Skills

1.1.0 Shows curiosity about objects and events.

1.1.1 Shows willingness to examine and organize objects and events in the environment. (See Sample Lesson: Earthquakes.)

4.8.22 Recognizes that there are continuous changes taking place in the earth.

Content	Continuum Skills
B. The greater the build up of tension or compressional forces within a fault zone, the higher the magnitude of the earthquake. 1. The intensity of an earthquake is measured by its magnitude. 2. A seismograph is used to measure magnitudes of earthquakes.	1.8.2 Applies scientific problem-solving techniques in everyday life situations. 4.1.0 Demonstrates knowledge of the processes of scientific inquiry. (Skills Unit IV E): Gathering and recording data.
C. Earthquakes in populated areas can injure or kill people as well as cause extensive property damage.	
D. Care in design, construction, and location of structures in earthquake-prone areas can minimize damage, injury, and loss of life in a major earthquake.	1.4.0 Takes an active role in solving social problems related to science and technology. 1.5.0 Weighs alternative scientific, economic, psychological, or social factors when considering possible solutions to some problems. (Skills Unit V F): Analysis of data must be consistent with conclusions. 4.3.0 Demonstrates knowledge of relationships between science and society. 4.3.1 Gives examples of ways in which the use of scientific knowledge has affected society.
III. Volcanism is the movement of magma and lava below and above the earth's surface.	3.5.0 Records observations accurately and organizes data and ideas in ways that improve their usefulness. 4.8.22 Recognizes that there are continuous changes occurring on earth.

Content

A. Movement of magma below the earth's surface forms laccoliths, sills, dikes, and batholiths.

B. When pressure forces magma to the surface through a weak spot in the crust, a volcano is formed.

   1. Volcanoes are classified by the type of eruption that occurs.
   2. Volcanoes, as with earthquakes, are found where there is a weakness on the earth's crust.

IV. The theories that account for the earth's movement and volcanic formation are called continental drift and plate tectonics.

A. According to the Theory of Continental Drift, the continents have been moving and are still moving.

B. According to the Theory of Plate Tectonics, the earth's crust is divided into large plates.

C. It is the movement of these plates that cause earthquakes and volcanoes.

   1. Movement of these plates are thought to be caused by convection currents within the mantle.
   2. When plates move apart under the ocean, a mid-oceanic ridge forms.

Continuum Skills

3.5.2 Tabulates information and uses tables.

(Skills Unit IV): The scientific method

1.2.1 Identifies simple cause-effect relationships.

1.5.2 Examines a variety of alternative viewpoints on scientific issues to form opinions about them.

1.6.2 Forms opinions only after seeking a variety of data and ideas.

1.8.0 Applies rational and creative thinking processes when trying to find relationships among seemingly unrelated phenomena and when seeking solutions to problems.

3.8.0 Applies appropriate mathematical concepts and skills in interpreting data and in solving problems.

3.3.1 Makes purposeful, objective observations.

Content	Continuum Skills
3. When two plates over ride each other, deep trenches and volcanoes form. 4. When two plates brush past each other, faults form such as the San Andreas fault in California.	4.8.22 Recognizes that there are continuous changes occurring on earth.
V. Students will find that many career opportunities in measuring and investigating earth-related phenomena and in construction are based on geology. A. Geologist B. Building inspector C. Seismic observer D. Seismologist E. Cartographer F. Surveyor G. Instrumentation technician H. Geophysicist I. Construction inspector	4.4.0 Demonstrates knowledge of science-related career opportunities and the preparation needed.

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UNIT EIGHT: THE HYDROSPHERE

Representative Objectives for This Unit

- Describe the composition of ocean water.
- Describe the major topographic features of the ocean's floor.
- Describe the effect of wind, the earth's rotation, the moon, and the sun on the ocean currents and the tides.
- Recognize the value of natural resources found in the ocean.
- Analyze the parts of the hydrologic cycle.
- Recognize the importance of fresh water as a natural resource.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.
- Identify and describe careers available in the field of oceanography.

Content

I. The ocean makes up 71% of the earth's surface and 97% of the hydrosphere.

  A. The composition of ocean water is mainly oxygen, hydrogen, and salts.

    1. The amount of dissolved salts in the ocean is called salinity.
    2. The dissolved salts come from volcanic activity, erosion of the land by rivers and glaciers, and wave action along the shoreline.

Continuum Skills

3.4.2 Gathers information from science textbooks, reference materials, films, and television. (Skills Unit VI): Library and research skills necessary to investigate topics of scientific interest.

4.2.2 Uses a cause-effect relationship to make a prediction.

4.8.0 Demonstrates general knowledge of science.

Content	Continuum Skills
B. Major topographic forms of the ocean are the continental shelf, the continental slope and the abyssal plain.	4.8.22 Recognizes that there are continous changes occurring in the earth.
1. Ocean ridges and magnetic reversal patterns are found in areas of sea-floor spreading. 2. Volcanoes in the ocean form seamounts, guyots, and islands.	
C. Marine life forms are found at all levels of the ocean.	1.3.2 Appreciates the interdependence of living organisms in the natural environment and the implications for continued survival.
1. Most marine life is found in the upper regions of the ocean. 2. The sun is the major limiting factor in determining where life is found in the ocean.	4.8.5 Recognizes that the sun is the source of energy for green plants and is basic to the growth and maintenance of living organisms.
D. Winds and the rotation of the earth cause ocean currents.	(See Sample Lesson: Ocean Currents.)
E. Ocean tides result from the gravitational attraction of the sun and the moon.	(Skills Unit VI): Responsible laboratory activities. 4.8.18 Demonstrates knowledge of the effects of moon and sun on ocean tides.
F. Oceanographers explore the ocean with specialized equipment.	
G. The oceans hold a wealth of resources that are of international importance.	4.8.25 Recognizes the value of using renewable energy sources instead of non-renewable sources.
H. The oceans play an important part in the hydrologic cycle.	

Content	Continuum Skills
II. The hydrologic cycle is the continuous movement of water from oceans and fresh water bodies to the air and land and then back to the bodies of water.	1.1.1 Shows willingness to examine and organize objects and events in the environment. 3.4.2 Gathers information from science textbooks, reference materials, films, and television.
A. The energy of the sun drives the water cycle by causing evaporation.	(Skills Unit VI): Library and research skills necessary to investigate topics of scientific interest.
B. Distillation and evaporation are ways of producing fresh water from salt water.	4.2.7 Describes interaction and reorganization of units of matter and their association with changes of energy.
C. Precipitation in the form of rain, snow, sleet, and hail return water to the earth.	4.8.28 Identifies the ocean as a major influence on weather.
III. Fresh water, which makes up only 3% of the hydrosphere, is an important natural resource.	3.4.2 Gathers information from science textbooks, reference materials, films, and television.
A. Only 15% of the earth's fresh water is available for use by plants and animals.	
B. Most fresh water is frozen in polar ice caps.	4.8.0 Demonstrates general knowledge of science.
1. Glaciers contain 3% of the available fresh water. 2. Icebergs could become an important source of fresh water.	4.8.25 Recognizes the value of using renewable energy sources instead of non-renewable sources.

Content

IV. Oceanography offers careers for those interested in both physical and biological sciences.

- A. Diver
- B. Ship's captain
- C. Sailor
- D. Shell collector
- E. Fish packer
- F. Aqua culture technician
- G. Clam digger
- H. Laboratory technician
- I. Fish and game warden
- J. Electrician
- K. Computer operator
- L. Marine geologist
- M. Oceanographer

Continuum Skills

1.10.0 Considers science-related careers and makes realistic decisions about preparing for such careers, taking into account abilities, interests, and preparation required.

1.10.1 Values the abilities, interests, and preparation required for a science-related career.

1.10.2 Assumes responsibility for making a realistic decision about the pursuit of a science-related career.

4.4.0 Demonstrates knowledge of science-related career opportunities and the preparation needed.

4.4.1 Compares the work performed by persons in various science-related occupations.

4.4.2 Identifies ways in which careers are science related.

UNIT NINE: THE PROPERTIES OF THE ATMOSPHERE AND THE PROCESSES OF WEATHER

Representative Objectives for This Unit

- Describe the parts of the atmosphere.
- Identify and describe the properties of the atmosphere and their effects on the weather.
- Recognize the use of different scientific instruments to collect meteorological data.
- Interpret the symbols on a weather map.
- Describe how severe storms can cause great damage to people and property.
- Recognize that weather predicting is both a difficult and important task.
- Identify and describe career opportunities in meteorology.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.

Content

I. The atmosphere is an ocean of air surrounding the earth.

   A. The atmosphere is made of four layers: the troposphere, the stratosphere, the mesosphere, and the thermosphere.

      1. The troposphere is the place where most of the earth's weather occurs.
      2. The jet stream and ozone layers, part of the stratosphere, have important effects on the earth.

         a. The jet streams are strong, high altitude winds important to the aviation industry.
         b. The ozone layer absorbs ultraviolet light.

Continuum Skills

3.4.2 Gathers information from science textbooks, reference materials, films, and television.

4.8.0 Demonstrates general knowledge of science.

4.8.28 Identifies the ocean as a major influence on weather.
(Skills Unit VI): Library and research skills necessary to investigate topics of scientific interest.

4.3.1 Gives examples of ways in which the use of scientific knowledge has affected society.

Content

Continuum Skills

B. Air is a mixture of gases.

C. Air has mass and takes up volume and, therefore, exerts a pressure.

1. Air pressure is measured with a barometer.
2. In the northern hemisphere, the earth's rotation causes a low pressure area which causes polar winds to blow from the east.
3. In the northern hemisphere, the earth's rotation causes a high pressure area. North of this area, winds blow from the west. South of this area, between it and the equator, winds blow from the east.

D. Air is in constant motion.

1. Changes in the temperature of the air cause air currents or winds.

2. Local wind patterns are influenced by physical factors.

    a. A sea breeze occurs when cool air over the water replaces warm air over the land.
    b. A land breeze occurs when cool air over the land forces warm air over the sea to rise.

Content

3. Global wind patterns are affected by unequal heating of the earth's surface.

    a. Cooler air moves towards the equator.
    b. The Coriolis Effect is the apparent shift of any materials moving above the surface of the earth due to the rotation of the earth.
    c. Major wind patterns are the doldrums, the horse latitudes, the prevailing westerlies, and the polar easterlies.

4. Instruments such as the anemometer and weather vane measure the speed and direction of the wind.

II. Weather is a temporary condition of temperature, wind, and humidity at a given place and time.

A. Humidity is the amount of water vapor in the air.

1. Relative humidity is the amount of water vapor air can hold at a given temperature.

2. A hydrometer and a wet-dry bulb thermometer are used to calculate relative humidity.

B. Clouds form when moisture in the air condenses on small particles of dust or other solid particles in the air.

1. Cirrus clouds are high altitude, wispy, and are made of ice particles.

Continuum Skills

4.3.3 Identifies types of data valuable in planning environmental changes.

4.8.26 Identifies major factors that cause weather changes and patterns.

(See Sample Lesson: Weather.)

(Skills Unit V): Responsible laboratory activities.

4.8.27 Identifies the effect of weather on the local environment.

4.8.28 Identifies the ocean as a major influence on weather.

4.8.0 Demonstrates general knowledge of science.

(Skills Unit IV): The scientific method.

        2. Cumulus clouds are very puffy and have flat bottoms.

            a. Cumulus clouds indicate fair weather.
            b. Cumulonimbus clouds form from cumulus clouds and can produce severe thunderstorms.

        3. Stratus clouds form sheets or layers across the sky.

            a. Fog is an example of a low stratus cloud.
            b. Gray overcast skies that block out the sun are called stratus clouds.

    C. Precipitation is water that falls from the atmosphere to the earth.

        1. Precipitation can be in the form of rain, snow, sleet, or hail.
        2. Violent storms can develop when cold and warm air masses meet or are forced to move rapidly.

III. Climate is the long term or average weather over a long period of time.

    A. Temperature and rainfall are important factors in determining climate.

    B. Climate in an area is affected by latitude, altitude, wind, ocean currents, distances from major bodies of water, and mountain ranges.

    C. Climate determines the predominant type of vegetation that grows in a particular area.

Content

D. Microclimates are formed when regional climates are changed by local influences.

  1. Cities often create microclimates.
  2. Smog is an example of an artificial microclimate.

    a. Small, very violent storms with twisting funnel-like clouds are called tornadoes.
    b. Large violent storms that form at sea are called hurricanes or typhoons.

IV. Weather prediction is an important but difficult task.

A. Constantly changing atmospheric conditions make prediction difficult.

B. The weather reported at different places at any given time is recorded on weather maps.

  1. Isobars connect lines of equal pressure.
  2. Symbols used on weather maps are used by all nations.

C. New technology has made the job of the meteorologist easier and more accurate.

Continuum Skills

3.4.3 Finds sources of information needed to solve a problem related to a specific topic.

4.3.1 Gives examples of ways in which the use of scientific knowledge has affected society.

(Skills Unit VII): Providing students with the opportunity to correct misconceptions.

4.8.27 Identifies the effect of weather on the local environment.

Content

V. Careers in meteorology require a background in mathematics and science.

   A. Broadcast technician

   B. Weather technician

   C. Fire science specialist

   D. Weather forecaster

   E. Meteorologist

   F. Climatologist

   G. Hydrologist

   H. Air-conditioning mechanic

Continuum Skills

1.10.0 Considers science-related careers and makes realistic decisions about preparing for such careers, taking into account abilities interests, and preparation required.

1.10.1 Values the abilities, interests, and preparation required for a science-related career.

1.10.2 Assumes responsibility for making a realistic decision about the pursuit of a science-related career.

4.4.0 Demonstrates knowledge of science-related career opportunities and the preparation needed.

4.4.1 Compares the work performed by persons in different science-related occupations.

4.4.2 Identifies ways in which careers are science related.

UNIT TEN: THE UNIVERSE AND SPACE

Representative Objectives for This Unit

- Describe the tools used by astronomers.
- Describe the members of the galaxy and the solar system.
- Classify stars according to their absolute magnitude and temperature.
- Analyze the cause and effect relationships between the earth, moon, sun, and tides and eclipses.
- Describe the physical features of the moon.
- Recognize that space exploration was done by many different people.
- Identify and describe careers available in astronomy and the space sciences.
- Accept responsibility for the safe and careful handling of laboratory materials and equipment.

Content

I. Astronomy is the study of heavenly bodies.

   A. Astronomers use special instruments to explore the universe.

      1. Telescopes use light and radio waves to explore objects in space.

         a. Reflecting and refracting telescopes use light to explore space.
         b. Radio telescopes use radio waves to explore more distant objects in space.

Continuum Skills

Content

2. Spectroscopes are used to examine the light given off by an object.
    a. Spectroscopes break light into its parts to form spectra.
    b. Studying the spectra helps astronomers to determine the temperature, composition, and absolute magnitude of stars.

B. Astronomers use light years (300,000 km/sec) as their basic unit of length.

II. The universe is made up of all the bodies in space and all the space between these bodies.

A. Some theories on the origin of the universe are:

1. Big Bang Theory
2. Steady State Theory
3. Pulsating Theory

B. The universe is made up of many galaxies.

1. A galaxy is a large group of stars classified according to its shape.
    a. Elliptical
    b. Spiral
    c. Irregular

Continuum Skills

3.1.1 Manipulates simple materials, apparatus, and equipment in a safe manner.

(See Sample Lesson: Spectra Analysis.)

(Skills Unit V): Responsible laboratory activities.

4.8.16 Demonstrates knowledge of basic differences between planets, stars, the solar system, the Milky Way Galaxy, and the known universe.

(Skills Unit IV): The scientific method.

4.8.13 Recognizes that the motion and path of celestial bodies are predictable.

Content

2. The Milky Way is an example of a spiral galaxy; it contains over 200 billion stars and many dust-gas clouds called nebulae.

C. Stars are spheres of gas which give off light.

1. Constellations are patterns of stars in the sky.

2. Stars are classified according to size and other characteristics.

    a. The Hertzsprung-Russell diagram plots stars according to the relationship between their absolute magnitude and their surface temperature
        1) Main sequence stars
        2) Giants and supergiants
        3) White dwarfs

    b. Other types of stars
        1) Variable stars are ones which become both brighter and dimmer.
            a) Novas
            b) Supernovas
            c) Cepheids
            d) Eclipsing variables
        2) Radio sources
            a) Quasars--"Quasi stellar radio source"
            b) Pulsar or neutron stars
            c) Black holes--areas where a star is believed to have disappeared and never returned.

Continuum Skills

3.8.0 Applies mathematical concepts and skills in interpreting data and in solving problems.

Content Continuum Skills

III. The solar system consists of all the objects that orbit the sun.

   A. Theories on the origin of the solar system include:

      1. Near-collision Theory
      2. Dust-cloud Theory

   B. Members of the solar system are the sun, planets, and other objects.

      1. The sun--a yellow star of average size

         a. Source of solar and radiant energy
         b. Structure of the sun
            1) Corona
            2) Chromosphere
            3) Photosphere
            4) Core
         c. Solar disturbances
            1) Solar flares, prominences, and auroras
            2) Sunspots
               a) Measure sun's rotation
               b) Interfere with radio communication
               c) Appear in cycles

Content	Continuum Skills

2. Planets and their satellites orbit the sun.
    - a. Inner planets are more earthlike. They include Mercury, Venus, Mars, and Earth.
    - b. Outer planets include Jupiter Saturn, Uranus, Neptune, and Pluto.
    - c. Asteroids are fragments of planet-like materials which orbit the sun between Mars and Jupiter.
    - d. Natural satellites or moons are objects that orbit the planets in space.

3. Comets are made up of frozen gases and cosmic particles that orbit the sun and form a "tail" when they come close to the sun.

4. Meteoroids are solid, rock-like objects that travel in space.
    - a. Meteors are meteoroids that enter the earth's atmosphere.
    - b. Meteorites are meteors that reach the earth's surface.
    - c. A meteor shower takes place when the number of meteors entering the earth's atmosphere increases to more than 60 miles per hour.

Content	Continuum Skills
IV. The earth and the moon A. The earth's movement 1. The earth revolves around the sun in 365.242 days. 2. The earth rotates on its axis once every 23 hours, 56 minutes, and 4 seconds. 3. The earth's axis is tilted at an angle of 23.5° making the length of daylight vary during the year and causing the seasons. a. Vernal equinox b. Autumnal equinox	4.8.14 Describes the regular movements of the earth and moon.
B. The moon's movement is caused by its rotation and revolution. 1. The moon revolves around the earth in 29.5 days. 2. The moon always has the same side toward the earth. 3. The different phases of the moon are caused by the position of the moon and earth with respect to the sun.	4.8.15 Demonstrates an appreciation and understanding of time/space relationships.

Content	Continuum Skills
a. Eclipses are caused when the shadow of the earth or moon blocks out some of the light from the sun. 1) Lunar eclipses occur when the earth passes between the sun and the moon. 2) Solar eclipses occur when the moon passes between the sun and the earth. 3) Eclipses do not occur every month because the sun, earth, and moon must all be in the same orbital plane for an eclipse to occur.	
b. The ocean tides are determined by the position of the moon and the earth. 1) The highest tides, spring tides, occur when the moon is in the new and full positions. 2) The lower high tides occur when the moon is in the first and third quarters. 3) The highest tides can be predicted, which makes it possible to warn the public in advance.	4.8.18 Demonstrates knowledge of the effects of moon and sun on ocean tides. (Skills Unit VI): Library and research skills necessary to investigate topics of scientific interest.

Content

C. Many physical features of the moon have been determined.

1. Diameter
2. Mass
3. Temperature
4. Gravity
5. Lack of atmosphere
6. Geological features
   a. Maria
   b. Plains
   c. Hills
   d. Rays
   e. Craters
   f. Moon rocks

V. Space exploration has greatly increased knowledge.

A. Space exploration has been possible only since adequate rocket powered vehicles have been available.

1. Rockets
2. Artifical satellites
   a. Unmanned
   b. Manned
3. Lunar exploration
4. Unmanned space probes
5. Space shuttle

Continuum Skills

1.9.0 Recognizes the values of science as a human endeavor representing all racial, ethnic, and cultural backgrounds.

1.9.2 Acknowledges that race, sex, or nationality should not constitute a barrier to scientific study.

1.9.3 Values the scientific contributions of human beings from varying cultural backgrounds.

(Skills Unit VII): Providing students with the opportunity to correct misconceptions.

4.8.17 Cites some of the accomplishments in humankind's exploration of space.

Content	Continuum Skills
B. Future space exploration will occur as technology improves.	
1. Space shuttle 2. Space labs 3. International cooperation	
C. Spin-offs from space research provide products of benefit to all people.	4.5.1 Matches significant discoveries to persons responsible.
1. Economic importance 2. Medical uses 3. Everyday uses	4.3.1 Gives examples of ways in which the use of scientific knowledge has affected society.
VI. Careers are available in astronomy, space science, and related fields.	4.4.0 Demonstrates knowledge of science-related career opportunities and the preparation needed.
A. Solar technician	
B. Aeronautical technician	4.4.1 Compares the work performed by persons in various science-related occupations.
C. Flight dispatcher	4.4.2 Identifies ways in which careers are science related.
D. Radio astronomy technician	
E. Space engineer	1.10.0 Considers science-related careers and makes realistic decisions about preparing for such careers, taking into account abilities, interests, and preparation required.
F. Astronomer	
	1.10.1 Values the abilities, interests, and preparation required for a science-related career.
	1.10.2 Assumes responsibility for making a realistic decision about the pursuit of a science-related career.

SAMPLE TEACHER-DIRECTED INSTRUCTIONAL SEQUENCES

Successful teaching begins with careful planning. Sample lessons are shown on pages 69-113.

The lesson plans follow the format of the seven-point, teacher-directed instructional sequences. The questions below need to be addressed when the teacher is designing these sequences.

- What is the specific objective? How will it be presented to the students?
- What is the value in achieving the objective?
- What learning activities must be modeled, explained, or illustrated for students?
- What guided group practice will be provided for the students?
- What independent practice or activity will be provided for the students?
- What provisions will be made for individual differences in learning styles?
- How will the lessons be evaluated?

SAMPLE LESSON I: MACHINES AND THEIR ADVANTAGES: MECHANICS

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: Use empirical and mathematical relationships to solve quantitative problems in physical science.

SKILLS EMPHASIZED: Thinking and writing

THINKING/COGNITIVE SKILLS: Application

1. Specific Objective: The students will be able to measure the force and calculate the work of an object being moved horizontally, vertically, and up an inclined plane.

2. Value to Students: The students will gain skills necessary to calculate the amount of work done on objects they encounter daily. They also will be able to apply this knowledge to courses they will take in the future.

3. Initial Instruction/Teacher Presentation: The teacher will introduce the concept of force, explaining what the unit called "the newton" is. He/she will also explain that work has a mathematical application that is "Force x Distance" or "newtons x meters." The teacher will explain that N x m has units of newton-meters or Joules (j). The teacher may use the chalkboard, an overhead transparency, or both to explain the ideas conceptually and mathematically. He/she will also present a filmstrip on force and work.

4. Guided Group Practice: The students may work in groups of 2, 3, or 4. They are to follow the procedure on the following page, record their observations, and answer the follow-up questions.

5. Independent Practice: The students will do the laboratory exercise as well as the following word problems. (See next page.)

6. Individual Differences and Learning Modalities:

   Remediation/Alternative Activities: Students who had difficulty grasping the concepts will be given an additional worksheet with "work problems". They will also reread the section in their text that explains force and work.

   Enrichment/Supplemental Activities: Students will use a metal cart with wheels in place of the wood block and repeat the procedures in the experiment.

7. Evaluation: The teacher will mark the students' laboratory data tables, conclusion questions, and work problems.

LABORATORY EXERCISE ON MEASUREMENT OF FORCE AND THE CALCULATION OF WORK

Materials:

Wood block with screw eye hook
Spring balance calibrated in newtons
Meter stick
Table over 2 meters long
An inclined plane (May use a wood board at least 1 meter long with one end propped up with books to create a slope.)

Procedures:

1. Attach the wood block to a spring balance calibrated in newtons. Place the block on a smooth table. Practice pulling horizontally on the spring balance to make the block move at a constant speed.
2. Move the block a distance of 1 m. Record the amount of force necessary to move the block uniformly. Calculate and record the amount of work you did.
3. Move the block 2 m. Calculate and record the amount of work you did after recording the amount of force you needed.
4. Now pull the block up the inclined plane while making the block slide at constant speed. Record the force reading. Measure the distance you moved the block. Calculate the amount of work you did, and record it.
5. With the spring balance still attached to the wood block, lift the block from the floor to a height of 1 m. Record the force required to lift the block. Calculate and record the amount of work done in lifting the block.

Data Table:

Direction of Movement of Block	Distance Moved (m)	Force	Work Done (N x m = Joules)
Horizontal			
Horizontal			
Inclined Plane			
Vertical			

Follow-up Questions:

1. Did you do more or less work moving the block a distance of 1 m compared with a distance of 2 m? Explain.
2. Did you do more or less work pulling the block up an inclined plane compared with pulling the block horizontally 1 m? Explain.
3. Did you do more or less work lifting the block vertically compared with pulling the block horizontally 1 m? Explain.
4. In which situation was there the greatest amount of work? Explain.
5. In which situation was there the least amount of work? Explain.
6. Can you predict whether using a metal cart with wheels will result in more work or less work than each of the ways in which you moved the wood block? Explain.

Work Problems:

1. John pushes a box across the floor with a force of 25 N. He pushes it 5 m. How much work has John done on the box?
2. Sally lifts a book with a force of 2 N. If the work she did was 2 j, how high did she lift the book?
3. Tom and John together push a large box with a force of 50 N. If they push the box a distance of 200 m., how much work has each boy done on the box, assuming equal amounts of work done by each boy?

SAMPLE LESSON II: OPTICS

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: Demonstrate manipulative skills in laboratory work that results in the recording of data.

SKILLS EMPHASIZED: Speaking, writing, reading, and listening

THINKING/COGNITIVE SKILLS: Application

1. Specific Objective: The students will be able to measure the focal lengths of various convex lenses.

2. Value to the Students: The students will gain knowledge of how convex lenses work in various optical instruments that they may use.

3. Initial Instruction/Teacher Presentation: The teacher will introduce the concept of refraction through a convex lens. He/she will explain what a focal point is and where this point will be with respect to a light source coming from an infinite distance.

   The teacher will demonstrate by using diagrams on the chalkboard, overhead transparencies, and/or filmstrips, the way light is bent as it enters and then leaves a lens.

4. Guided Group Practice: The students will work in groups of 2, 3, or 4. They will follow the procedure described on the next page. After they have made and recorded their observations on a data table, class members will answer the conclusion questions.

5. Independent Practice: After measuring focal lengths, the students will draw ray diagrams of light passing through the various convex lenses (the ray originating from an infinite distance). Students will label the diagrams and submit them for teacher evaluation.

6. Individual Differences and Learning Modalities:

   Remediation/Alternative Activities: The students will reread the section in the text about lenses. They will construct and label a ray diagram for both a convex and a concave lens. They will explain, in written form, what the difference is between a real image and a virtual image.

   Enrichment/Supplemental Activities: The students can write a brief research paper on how lenses are used in the human eye, a microscope, a telescope, or a camera. Class members may draw and label diagrams to show how the light is refracted in each kind of instrument.

7. Evaluation: Students will turn in their laboratory exercises to the teacher for his/her evaluation. During a discussion, students and teacher will review answers to the conclusion questions and examine the ray diagrams drawn by the students.

LABORATORY EXERCISE ON DETERMINING FOCAL LENGTHS USING VARIOUS CONVEX LENSES

Materials:

3 convex lenses of varying curvatures
Metric rulers
White paper

Procedures:

Part A
1. Hold a sheet of white paper in the sunlight.
2. Place each lens in the path of the sunlight, between the sunlight and the paper. Focus the light by moving the lens back and forth until you are able to see a small spot of light on the paper. This is the focal point.
3. Measure the distance from the lens to the focal point on the paper to the nearest cm.
4. Record the measurements on your data table for each lens.

Part B
1. Hold the paper vertically while facing a window.
2. Hold one of the lenses between the paper and the window. Focus by moving the lens until an image of the scene outside the window appears clearly on the paper.
3. Measure the distance between the lens and the paper. Record the data.
4. Repeat the procedure, using the other lenses.

Data Table:

Lens	Focal length in cm.	Distance between lens and image on paper in cm.
A		
B		
C		

Follow-up Questions:

1. Which lens had the longest focal length?
2. Which lens had the shortest focal length?
3. How do the shapes of the lenses mentioned in questions 1 and 2 differ?
4. How did the image of the scene outdoors differ from the actual scene?
5. Were the images of the outdoor scene real or virtual? Explain.
6. What is meant by "refraction through a convex lens"?

SAMPLE LESSON III: CIRCUITS

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: Construct an electrical system and explain how and why it works.

SKILLS EMPHASIZED: Reading and writing

THINKING/COGNITIVE SKILLS: Application

1. Specific Objective: The students will construct a simple circuit, a series circuit, and a parallel circuit.

2. Value to Students: The students will have a greater knowledge of how circuits are constructed and how they work in the students' own environments.

3. Initial Instruction/Teacher Presentation: The teacher has already introduced the concepts of electricity, the electrical units, and open and closed circuits. He/she will now explain the differences between simple, series, and parallel circuits. He/she will use the chalkboard, overhead transparencies, and/or a filmstrip to explain how the circuits are formed. He/she will instruct the students as to how to construct all three kinds of circuits.

4. Guided Group Practice: The students may work in groups of 2, 3, or 4. They are to follow the procedure described on the next page in constructing a simple circuit, a series circuit, and a parallel circuit. Class members are to draw all three circuits on plain paper and label the drawings. Students are to answer the follow-up questions.

5. Independent Practice: The students will help to construct the three kinds of circuits described in the "procedure" of the laboratory exercise. They will draw the three types and label each drawing. In addition, each student will write a one-page explanation of which kind of circuit system he/she thinks is in his/her own home. Class members will give reasons for their choices.

6. Individual Differences and Learning Modalities:

   Remediation/Alternative Activities: Students who need further help will reread the section on circuits in their books. They will take notes and draw the diagrams of the three circuits. They will then construct the three circuits under the teacher's supervision.

Enrichment/Supplemental Activities: The students will construct a parallel circuit and a series circuit with various kinds of electrical devices in addition to those constructed with light bulbs. Suggested electrical devices are a buzzer, a bell, and a small electric motor. Students will draw a diagram of each of the circuits constructed.

7. Evaluation: The teacher will lead a discussion with the class on the advantages and disadvantages of each kind of circuit. He/she will evaluate the circuit set-ups of each of the groups of students and will mark them. The teacher will also mark the students' drawings, answers to the follow-up questions, and their one-page papers.

LABORATORY EXERCISE ON THREE CIRCUITS: THE SIMPLE, THE SERIES, AND THE PARALLEL

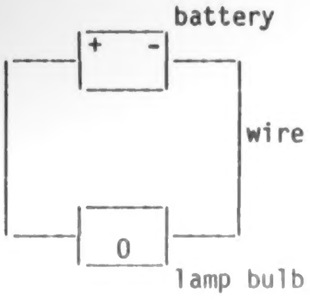
Materials:

3 batteries
7 sockets and light bulbs
Screwdriver
12 pieces of insulated copper wire (30 cm each)

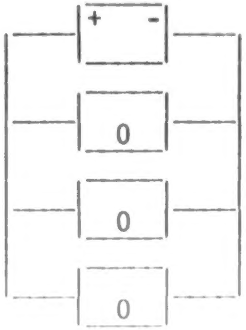
Procedure:

1. Follow the diagrams to construct three different circuits.
2. Prepare a drawing of each of the circuits on plain paper. Label each of the drawings.
3. Answer the follow-up questions.

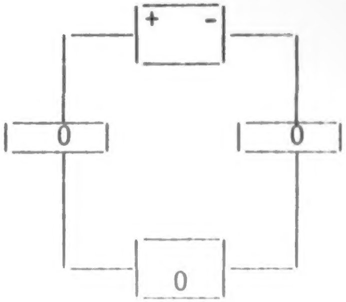
Simple Circuit



Parallel Circuit



Series Circuit



Follow-up Questions:

1. How does the brightness of the lights in the series circuit compare to the brightness of the light in the simple circuit? How do the lights of the series circuit compare in brightness to the lights of the parallel circuit?
2. How does the brightness of the lights in the parallel circuit compare to the brightness of the light in the simple circuit?
3. If you unscrew one light bulb in the series circuit, what happens to the others?
4. If you unscrew one light bulb in the parallel circuit, what happens to the others?
5. Why are the lights dimmer in the series circuit?
6. When one light bulb goes out, why do all the light bulbs in the series circuit go out?
7. Which kind of circuit do you think is the type used in your own home?

SAMPLE LESSON IV: ELEMENTS, COMPOUNDS, AND MIXTURES

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: Classify matter on the basis of physical and chemical properties.

SKILLS EMPHASIZED: Speaking, writing, reading, and listening

THINKING/COGNITIVE SKILLS: Application

1. Specific Objective: The students will be able to analyze 10 different solutions, using pH and litmus papers.

2. Value to the Students: The skills developed by the students will enable them to determine whether or not some chemicals in their daily environment may be harmful.

3. Initial Instruction/Teacher Presentation: The teacher will introduce the concept of acids and bases through lecture/discussion, using the chalkboard, overhead transparencies, books, and/or filmstrips. The teacher will demonstrate how to use litmus and pH papers to determine if solutions are acids and bases. He/she will also instruct the students how to record their observations and how to form a valid conclusion.

4. Guided Group Practice: The students will work with partners and will follow the procedure outlined on the following page. After class members have made and recorded their observations, the teacher can utilize the follow-up questions to initiate a class discussion.

5. Independent Practice: The students will take pH paper and litmus paper home and will test five chemicals found in their homes. They are to record the data and write a short report on what they find.

6. Individual Differences and Learning Modalities:

   Remediation/Alternative Activities: The students who did not grasp the concepts can be given an additional reading assignment explaining acids and bases. Worksheets can be provided with follow-up questions on the reading.

   Enrichment/Supplemental Activities: Students can make their own acid/base indicators to test for acids and bases. They can boil purple cabbage leaves and collect the juice. This juice will be their indicator for pH. They can determine their own color scale for pHs, using known solutions as guides.

7. Evaluation: Students will participate in a discussion based upon responses to the follow-up questions and/or write an essay explaining the differences between acids and bases. The teacher will mark their laboratory exercise worksheets.

LABORATORY EXERCISE ON THE TESTING OF 10 UNKNOWN SOLUTIONS WITH pH PAPER AND LITMUS PAPER

Materials:

Litmus paper
pH paper
10 solutions (lemon juice, vinegar, shampoo solution, alcohol, water, baking soda solution, starch solution, laundry solution, dilute HCl, a lemon-lime or any clear carbonated beverage.
Dropper bottles
Colored pencils
Data sheets
Rulers
Paper towels

Procedures:

1. The student will copy the pH color scale for his/her own reference.
2. They will test each of the 10 unknown samples of chemicals with the litmus paper.
3. They will then test each of the 10 unknown samples with pH paper and will record each sample's pH to the nearest whole number.
4. They will then complete their data tables, indicating which of the solutions are bases and acids and identifying which are strong or weak. (See attached sheet for data table.)

Follow-up Questions:

1. What is the difference between acids and bases with respect to their chemical make-up?
2. What are three properties of bases? Name three properties of acids.
3. Which unknown solution was the strongest acid? Which was the strongest base?
4. Which unknown solution was the weakest acid? Which was the weakest base?
5. Can you draw any correlation from the answers to questions 3 and 4?
6. Were any of your solutions neutral? If so, which one(s)?
7. What are neutral solutions?

DATA TABLE FOR RESULTS OF SOLUTION TESTS

Unknown Solution	Base	Acid	Neutral Solution	pH Number	Strong/Weak Acid/Base
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					

5 Chemicals at Home

1					
2					
3					
4					
5					

SAMPLE LESSON V: RADIATION

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: Records observations accurately and organizes data and ideas in ways that improve their usefulness.

SKILLS EMPHASIZED: Speaking, writing, reading, and listening

THINKING/COGNITIVE SKILLS: Analysis

1. Specific Objective: The students will demonstrate the rate at which radioactive atoms decay.

2. Value to Students: The students will have greater insight and understanding when assessing the issues of the nuclear age.

3. Initial Instruction/Teacher Presentation: The teacher will introduce the concept of radioactive half-life. He/she will explain that the radioactivity of an element or isotope is measured by determining the specific period of time during which half of the radioactive atoms will decay. The teacher may use the chalkboard, overhead transparencies, filmstrips, etc. to help explain this concept. He/she should instruct the students in how to tabulate their data and how to record the data in graph form.

4. Guided Group Practice: The students may work in groups of 2, 3, or 4. They are to follow the procedure described on the next page, construct a data table, construct a graph, and answer the follow-up questions.

5. Independent Practice: The students will use the school library to find and copy a graph of a real radioactive decay curve of an element. They will compare what they discover in this laboratory exercise with what they find in the library. Class members will write a brief paper explaining the similarities and differences.

6. Individual Differences and Learning Modalities:

   Remediation/Alternative Activities: Students will reread and outline the section in their text on radioactivity. They will repeat the laboratory investigation under the close supervision of the teacher.

   Enrichment/Supplemental Activities: The students will write a library research paper on the beneficial uses of radioactivity. They may want to research the effects of radioactivity on cancer treatments or the usefulness of radioactive isotopes in chemical research. The report should be two pages long.

7. Evaluation: The students will participate in a discussion with the teacher about their experimental results. They will compare the graphs that they have drawn with all other graphs. The students' independent practice papers and their laboratory reports will be marked by the teacher.

LABORATORY EXERCISE SIMULATING RADIOACTIVE DECAY OF AN ELEMENT

Materials:

50-one-inch cardboard squares, each marked on one side
Large shoe box with cover
Graph paper

Procedures:

1. Students will place the squares in a closed box and shake for about 30 seconds using a tumbling motion to assure that the squares will turn over.
2. Students then open the box and remove all squares with the marked side up. These represent atoms which have decayed.
3. Students count the numbers of squares remaining and record the total on the data table.
4. Students repeat this procedure until all the squares have been removed.
5. Students prepare a graph containing data. They mark the number of each trial along the bottom of the graph paper. They also mark the number of remaining squares along the left side of the graph paper. They use the two numbers--trial number and squares remaining after each trial--to locate each point on the graph. Finally, they draw a smooth curve through these points. (See accompanying sheets for sample data table and graph showing some items to be comleted by students.)

Follow-up Questions:

See attached sheets for questions.

Name ____________

RATE OF RADIOACTIVE DECAY DATA SHEET*

Title: Investigating the Rate of Radioactive Decay

Purpose: To study the rate at which radioactive atoms decay.

Data:

(Data will vary.)

TRIAL	SQUARES REMAINING	TRIAL	SQUARES REMAINING
1		11	
2		12	
3		13	
4		14	
5		15	
6		16	
7		17	
8		18	
9		19	
10		20	

*Use the graph provided on the next page to plot the above results.

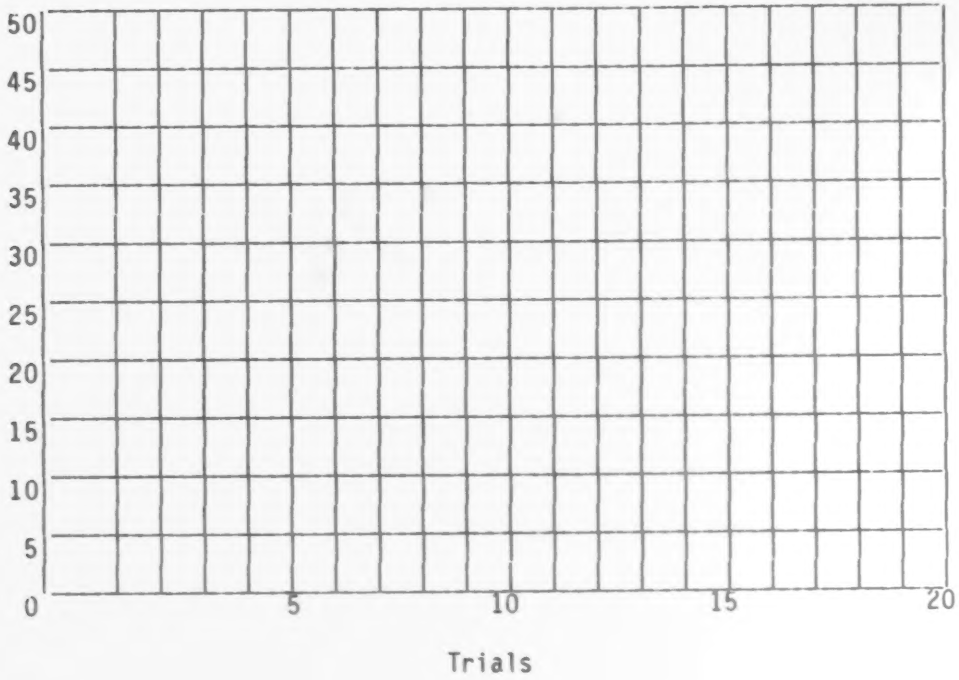
Questions:

1. How many trials were needed to remove all the squares? (Varies)
2. At which trial were most of the squares removed? (Should occur during earlier trials)

3. At which trial were the fewest squares removed? (Should occur during later trials)

4. What percentage of squares were removed on the first trial? ____________________
What percentage would you have expected? (Should expect 50%)

GRAPH OF RESULTS



SAMPLE LESSON VI: MINERALS

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: The student gathers the information needed for developing or testing inferences and hypotheses by making purposeful, objective observations of things and events.

SKILLS EMPHASIZED: Thinking, speaking, and writing

THINKING/COGNITIVE SKILLS: Analysis

1. Specific Objective: The student will identify minerals by testing each sample for its color, luster, crystal structure, reaction to acid, and specific gravity. From the results, the student will be able to conclude what he/she has by comparing the results to known data.

2. Value to Students: By performing a series of simple tests, students can identify an unknown substance. Students recognize the importance of doing more than one test before coming to a conclusion.

3. Initial Instruction/Teacher Presentation: The teacher introduces the concept of minerals and how they are identified by their characteristics using various tests, through lecture/discussion. The teacher then demonstrates how one tests for color, streak, luster, crystal structure, acid reaction, and specific gravity by demonstrating various tests to the class.

   Materials: Hand lens, 10% HCl in dropper bottles, unglazed tile, balance, beaker of water, string, samples of unknown minerals (numbered), and data sheet listing characteristics of known minerals. (See accompanying page.)

the color of the samples of unknown minerals.
each mineral on the tile and record the color of the mark
the luster of each mineral. (Is it bright, shiny, dull, meta
the number of sides or faces on each sample mineral and compare
information the teacher gave you. Record the crystal shape. If the
shape, look for small crystals with the hand lens. Report whe
any crystals.
one drop of acid on each sample mineral. Bubbles indicate a
mineral. (Do not put acid on your skin.)

f. Weigh each sample mineral while it hangs in the air, and then while it hangs in a beaker of water. Calculate the specific gravity for each mineral in the following way:

   1. Determine weight in the air
   2. Determine weight in the water
   3. Subtract 2 from 1. This difference equals the weight of the same volume of water.
   4. Determine specific gravity by dividing 1 by 3.

g. After completing each test with each of the unknown minerals, compare the results with the corresponding figure on the data sheet of known minerals. (See the next page.) Identify which minerals you have.

Follow-up Questions:

Write a paragraph describing each of the unknown minerals. Be sure to tell what you think it is and why.

5. Independent Practice: Using the skills and concepts developed by identifying minerals, students will use their knowledge to write a paper on how they will determine if a "gold coin" they found in the parking lot is really "gold."

6. Individual Differences and Learning Modalities

Remediation/Alternative Activities: Students are to reread and review the text. The teacher will examine each test individually with the groups that are having problems and will help the groups gather data for the first sample. The teacher will also repeat the tests or instruct other students to assist those having difficulties.

Enrichment/Supplemental Activities: Students can grow crystals of sugar, salt, copper sulfate, or other chemicals available at school or home.

7. Evaluation: Student data sheets, follow-up questions, and independent practice will be marked. Evaluation will be based on the accuracy of students' observations and on whether the students' conclusions are consistent with their own observations. The laboratory skills and procedures utilized by the students during the exercise will also be appraised.

Name ______________________________

MINERAL IDENTIFICATION

DATA SHEET

Data/Questions:

Mineral Number	Color	Scratch Test	Luster	Number of Faces	Acid Test	Specific Gravity	Conclusion
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

TABLE OF MINERAL PROPERTIES

Mineral	Hardness	Streak	Cleavage/ Fracture	Specific Gravity	Luster	Color	Other Properties
Calcite	3	White	Cleavage or fracture	Light (2.7)	Glassy	Clear	Fizzes in acid. *Double refraction
Hematite	5.5-6.5	Red-brown	Fracture	Heavy (5.30)	Dull or earthy	Red-brown	Source or iron
Corundum	9	Colorless	May look like it has cleavage	Medium (3.9-4.1)	Glassy or sparkling	Brown, green, red, blue	Some varieties used as gemstones. Samples may be 6-sided.
Magnetite	6	Black	May look like it has cleavage	Heavy (5.2)	Metallic	Black	Attracts magnet/source of iron
Quartz	7	Colorless	Fracture (like glass)	Light (2.65)	Glassy or waxy	Colorless unless impurities; smoky from radiation	Often shows well-formed crystals
Halite	2.5	Colorless	Good cleavage	Light (2.1)	Glassy to dull	Colorless unless impurities	Tastes salty transparent cubes
Graphite	1.2	Black	Good cleavage	Light (2.3)	Greasy	Steel gray-black	Feels greasy. Blackens fingers

*A double image is produced when Iceland Spar, a type of calcite, is placed over printed material.

TABLE OF MINERAL PROPERTIES (Continued)

Mineral	Haredness	Streak	Cleavage/ Fracture	Specific Gravity	Luster	Color	Other Properties
Talc	1	Colorless	Good cleavage	Light (2.8)	Pearly soapy	Greenish-white (varies)	Soft, feels greasy
Galena	2.5	Gray to black	Good cleavage	Heavy (7.6)	Metallic	Blue to black to lead gray	Often looks like metallic cubes
Pyrite	6.5	Greenish-black	May show cleavage	Heavy (5.0)	Metallic	Brassy yellow	May resemble gold
Orthoclase	6	Colorless	Good cleavage	Light (2.5)	Often looks pearly or glassy	Usually white to gray	Common in rocks
Mica	2-3	Colorless	Good cleavage	Light (3)	Glassy or pearly or shiny	Varies white to dark	Light-colored mica, transparent, in thin sheets; dark mica, smoky color

SAMPLE LESSON VII: EARTHQUAKES

COURSE: Physical and Earth Science AB

SKILLS EMPHASIZED: Reading and computing

THINKING/COGNITIVE SKILLS: Analysis

1. Specific Objective: The student will interpret data to calculate the distance cities are from an earthquake and to determine the epicenter of that earthquake.

2. Value to Students: The student develops the skill to read graphs and to use that information to solve a particular problem. The problem-solving skill can be used in situations in everyday life.

3. Initial Instruction/Teacher Presentation: The teacher explains, using lecture/discussion, demonstrations, and audiovisual resources, the use of seismographs to determine the distance a city is from an earthquake, the differences between primary and secondary waves, and how an epicenter of an earthquake is determined. Overhead transparencies of travel-time graphs and seismograms can be used. With the use of overhead transparencies, the teacher should demonstrate how to read a seismogram and how to calculate the distance a city is from a particular earthquake. The teacher should also demonstrate how to use a compass to measure in kilometers the distance a city is from the epicenter. The teacher should point out to students that a particular scale is used to measure kilometers.

   Materials: Pencil, compass, travel-time graphs, seismograms, maps, paper, rulers

4. Guided Group Practice: Students should work in pairs, reading the directions on the laboratory sheet and answering questions 1-4. The teacher should verify that students understand the lesson before they complete the data table. (See accompanying laboratory sheets.)

   After the teacher verifies that everyone understands, the students should use Figure 3 (three seismograms) to complete the data table.

   Next, the students should determine the epicenter of the earthquake by using a compass and the calculated data. The class members are to draw three circles on the map (Figure 4). The radius of each circle is determined by the distance that particular city is from the earthquake. To measure the radius of each circle, the student places the pin of the compass on the zero mark scale and moves the pencil to the correct number of kilometers. Class members should remember that the scale is in hundreds of kilometers. They should draw the circle after putting the compass pin in the city point on the map and repeat this procedure for each city. The location of the epicenter is the place where all three circles intersect.

   The students should then answer the questions on the laboratory sheet.

5. Independent Practice: From the given data and the conclusion reached in the guided group practice, students are to calculate the distance Los Angeles was from the epicenter and the time it would take the P and S waves from the earthquake to reach Los Angeles. Students must show all their calculations and the methods they used for getting their answer.

6. Individual Differences and Learning Modalities

   Remediation/Alternative Activities: The students should reread the material if necessary. Students who do not grasp the concepts should work with students who do.

   Enriched Supplemental Activities: Students who understand the lesson can help those who are having problems. Students can do research concerning attempts that have been made to predict earthquakes and then write an essay on the topic.

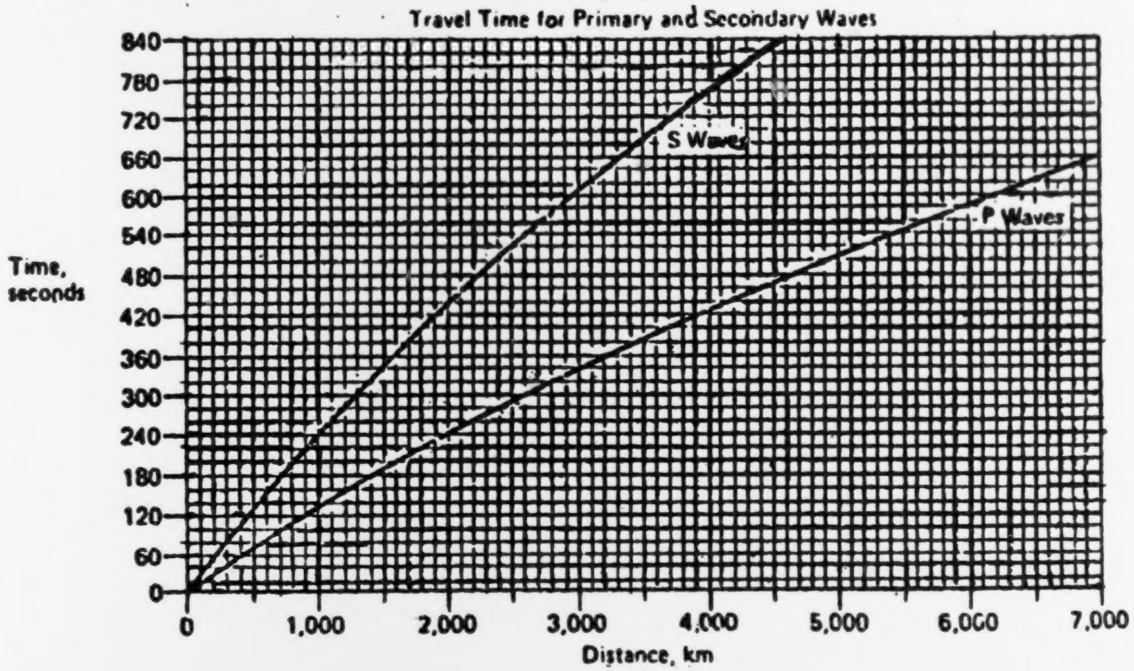
7. Evaluation: Responses to questions, the completed data table, and the independent practice assignment should be collected and marked. Evaluation should be based on how accurate and precise the student was in utilizing the given data.

NAME________________________________ PERIOD______________

INTERPRETING TRAVEL-TIME GRAPHS AND SEISMOGRAMS

Scientists use seismograms and travel-time graphs to locate earthquake epicenters. You will now study and interpret some examples of these situations.

An earthquake releases energy that travels through the earth in the form of waves. Primary and secondary waves travel at different speeds. Both kinds of waves start out at the focus of the earthquake at the same time. However, they reach distant seismograph stations at different times. The graph below shows how this works. Study the graph. Then use it to answer the questions below.



1. Suppose a seismograph station is 3,000 km from the focus of an earthquake. How long, in seconds, does it take the P wave to arrive? ____________________.

2. How long does it take the S wave to arrive? ____________________.

3. The difference in arrival time for P and S waves is called the lag time. What is the lag time for this earthquake? ____________________.

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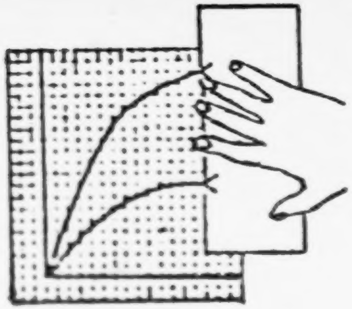
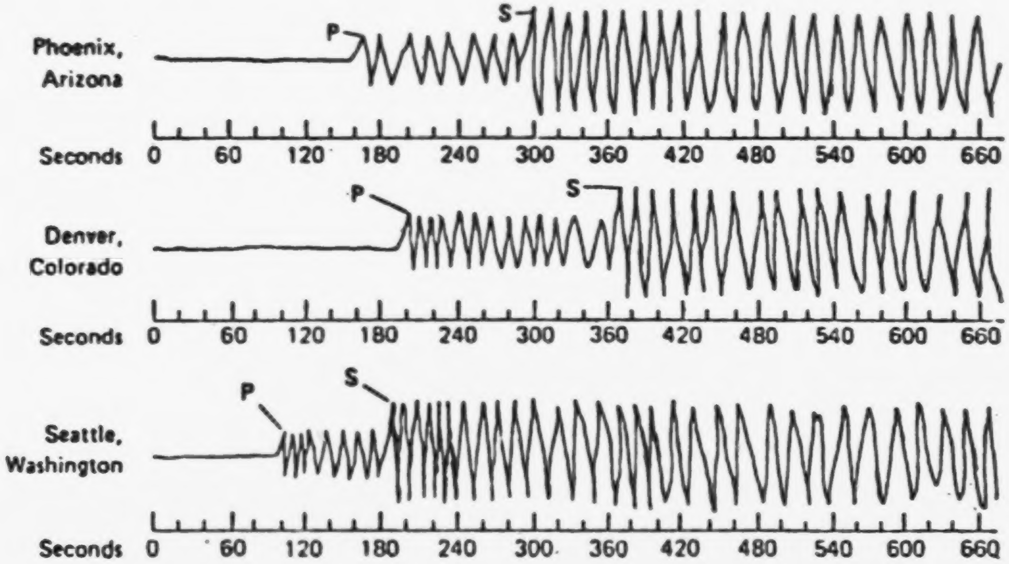


Suppose you know the lag time between the arrival of the P and S waves at a place. You can then use the graph to find out how far the place is from the epicenter. Take a sheet of paper and hold it against the vertical axis of the graph. On the edge of the paper, mark two points--one at the zero mark and the other at the amount of the lag time. (If the lag time is 30 seconds, the marks on your paper will be at the points for 0 seconds and 30 seconds on the vertical axis.) Slide this paper to the right. Keep the edge parallel to the vertical axis.

Find a place on the graph where the distance between the two curves is the same as the distance between the two points on the paper. Look down at the horizontal axis at the edge of your paper. The point marked there is the distance from the epicenter that would have this particular lag time. Therefore, your place must be this distance from the epicenter.

4. At your location, you record a lag time of 180 seconds between the P and S waves. How far are you from the epicenter? ______________________________.

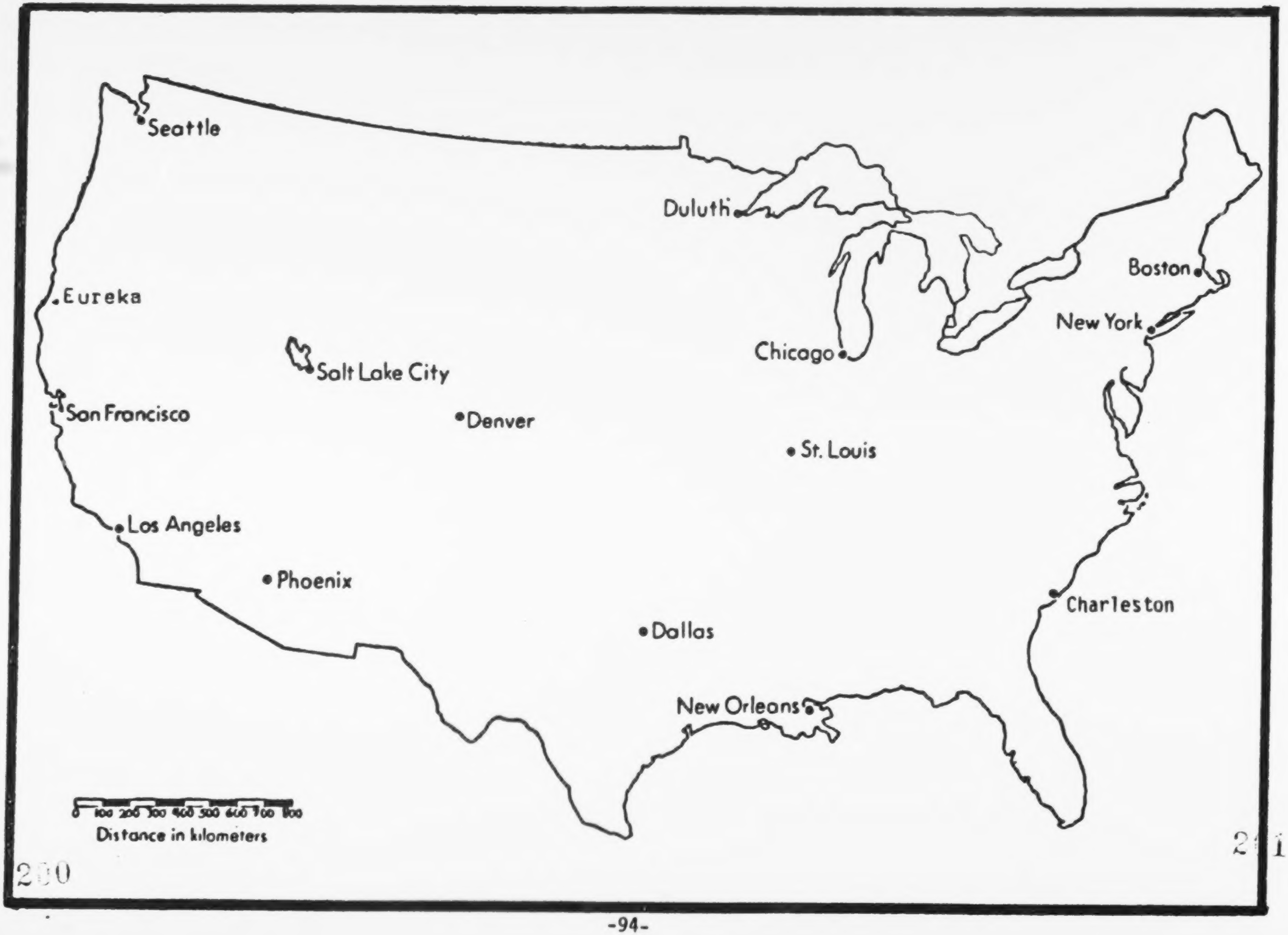
On November 9, 1980, an earthquake struck the West Coast of North America. The seismograms below recorded the number of seconds after 2:27 p.m., Pacific Time, that the P and S waves reached three different cities.



For each city, determine the arrival time in seconds for the P and S waves. Record these times in the table below. To determine the lag time, subtract the P arrival time from the S arrival time. Record your answers in seconds. Then use the lag time and the travel-time graph on the preceding page to determine the distance of each city from the earthquake's epicenter.

Seismograph Station	Arrival Time After 2:27, Seconds		Lag Time, Seconds	Distance, Kilometers
	P Waves	S Waves		
Phoenix, Arizona				
Denver, Colorado				
Seattle, Washington				

MAP FOR DETERMINING LOCATIONS IN INTERPRETING TRAVEL-TIME GRAPHS AND SEISMOGRAMS


Seattle
Eureka
San Francisco
Los Angeles
Phoenix
Salt Lake City
Denver
Dallas
Duluth
Chicago
St. Louis
New Orleans
Boston
New York
Charleston
0 100 200 300 400 500 600 700 800
Distance in kilometers

Follow-up Questions

1. Could you locate the epicenter of the earthquake after drawing the first circle? Why or why not?
2. Could you locate the epicenter of the earthquake after drawing the second circle? Why or why not?
3. Could you locate the epicenter of the earthquake after drawing the third circle? Why or why not?
4. Near what city was the epicenter of the earthquake located?
5. Did this earthquake occur in an area where earthquakes are expected? Why or why not?
6. If you lived in a coastal city, what effect might the earthquake have had on the area?

SAMPLE LESSON VIII: OCEAN CURRENTS

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: Describe the movements of the major ocean currents.

SKILLS EMPHASIZED: Listening and writing

THINKING/COGNITIVE SKILLS: Application

1. Specific Objective: The student will be able to demonstrate that temperature and salinity influence the density of water and, therefore, ocean currents.

2. Value to Students: The student will understand that the factors which determine ocean currents can also influence local weather and fishing conditions.

3. Initial Instruction/Teacher Presentation: The teacher introduces the concepts of density, salinity, and ocean currents through lecture/discussion, using audio-visual materials and demonstrations. The teacher can use an overhead transparency to show the location and direction of major ocean currents. He/she should demonstrate the Guided Group Practice to the class.

   Materials:
   Plastic shoe box (one per lab station)
   Metric ruler, snap-type clothespin
   250 ml beaker, pencil, food coloring, graduated cylinder, stirring rod,
   tap water, warm water, thermometer, saltwater (10% solution prepared in advance),
   2 styrofoam cups per laboratory
   Laboratory sheets (See accompanying pages)

4. Guided Group Practice: Students work in groups of 3 or 4 to perform the laboratory activity "Causes of Currents" (see page 98). Students are to read the description of the procedure and follow directions. Students are to draw diagrams and answer the follow-up questions.

5. Independent Practice: On a map of the world, students are to draw in the major ocean currents. They are to indicate the directions of flow and whether the currents are warm or cold. The drawing should also include the names of the currents. After drawing and labeling the major currents, the students are to form hypotheses as to why the currents are warm or cold and where they might find a good fishing area.

6. Individual Differences and Learning Modalities:

Remediation/Alternative Activities: Students should reread the procedure. The teacher will demonstrate how to do the experiment again for individual groups who are having problems.

Enrichment/Supplemental Activities: Students select a place to put a bottle with a message in it into the ocean. If the rate of the California current is 7 km per day, how far will the bottle travel in one day? One month? One year? Where would class members look for their bottle in one week?

7. Evaluation: Students participate in a discussion based upon responses to the follow-up questions. The teacher will collect and mark student answer sheets, maps, statements of hypotheses, and drawings.

CAUSES OF CURRENTS

Purpose: To demonstrate that temperature and salinity influence the density of water and, therefore, currents.

Procedure:

1. Pour about 3 liters of warm water (about 50°C) into a plastic shoe box. The water level should be about 3 or 4 cm below the top of the box.
2. Push an empty styrofoam cup into the water in the shoebox. Clamp the cup to the edge with a clothespin. (See Figure 1.)

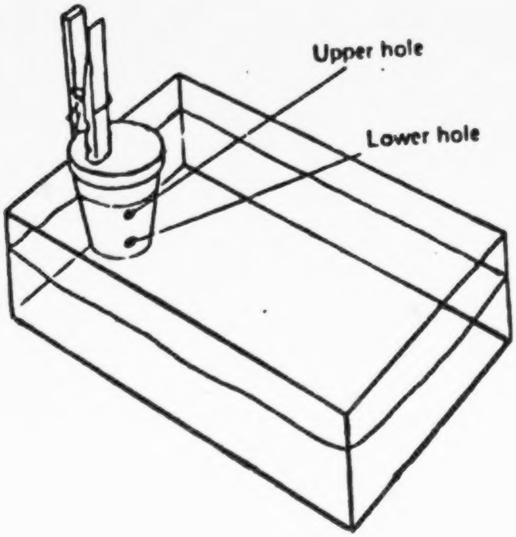


Figure 1

3. Place 2 ice cubes and 100 ml of cold water into the cup. Add 2 or 3 drops of food coloring to the cup of cold water. Stir until the coloring mixes completely with the water. Allow the water in the cup and box to settle until no motion is visible.
4. Use a pencil point to poke two holes in the styrofoam cup. One hole should be just below the water level in the shoe box. The other hole should be 2 cm from the cup's bottom.
5. Observe carefully the pattern in which the colored water moves out of the cup into the shoe box. When the movement of water has slowed or stopped, empty the cup and the shoe box into a sink.

6. In the space provided on the lab sheet, draw a diagram of the path which the tinted cold water took. Be sure to show where the water came out of the cup. Also show where it moved in the shoe box.

7. Again fill the shoe box with 3 liters of water. The water should be at room temperature (about 21°C). Attach a new cup to the shoe box as you did in step 2. Put 100 ml of saltwater, also at room temperature, into the cup. Add 2 or 3 drops of food coloring to the saltwater. Stir thoroughly.

8. Repeat steps 4 and 5. Again observe the way in which the colored water moves. Draw a diagram showing this motion in the space provided. Be sure to indicate where the water left the cup.

A. Diagram of Movement
of Tinted Cold Water

B. Diagram of Movement
of Tinted Saltwater

Follow-up Questions

1. Which hole did the cold water come out of? Explain how density causes this behavior.
2. Which hole did the saltwater come out of? Why?
3. Where did the saltwater go when it emerged from the hole in the cup?
4. At what locations on the earth would you expect to find very cold water entering an ocean? How would this cold water cause a current through the difference in density?
5. Evaporation of water near the surface will make ocean water more salty. How might this extra-salty water move in a current?
6. What results would you expect if warm water was placed in the cup and cold water was on the outside? Why?
7. How would a difference in temperature affect the organisms that live in the ocean?

SAMPLE LESSON IX: WEATHER

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: Recognize that climates of an area are determined by various factors such as latitude, altitude, and geographical features.

SKILLS EMPHASIZED: Thinking and reading

THINKING/COGNITIVE SKILLS: Application

1. Specific Objective: The student will be able to construct graphic displays of the annual precipitation and temperature of different cities in the U.S.

2. Value to the Student: The student will understand how the geographic location of a city determines the area's climatic patterns which could be a factor in selecting where he/she may want to live or move.

3. Initial Instruction/Teacher Presentation: The teacher introduces the concept of climates and the geographical factors that influence climate by using lecture/discussion and/or audio-visual materials. The teacher should show students the locations (on a map) of various cities referred to in this lesson.

   Materials
   Data sheets and questions, 6 sheets of graph paper per group,
   colored pencils, atlas or U.S. maps

4. Guided Group Practice: One student works with another student to plot data on graph paper. Each student is to prepare 3 graphs and answer the follow-up questions, based on data for all 6 cities.

   Procedure:
   1. Set up graphs. (See sample.)
   2. Plot temperature readings, using a line graph.
   3. Plot rainfall (precipitation) readings, using a bar graph.
   4. Be sure to label the graphs.
   5. Answer the following questions, using all six graphs.

   Follow-up Questions:
   a. Which city or cities have the coldest and longest winter?
   b. Which city or cities have the warmest winter? Why?
   c. Which city has a hot, rainy summer? Explain why this might happen.
   d. Which city has a warm, wet winter?
   e. If you had a choice, which of the cities would you move to? Why?

5. Independent Practice: Students should calculate the annual mean temperature and precipitation for each of the cities. Students are then to compare the annual means and the data in the graphs they constructed.

6. Individual Differences and Learning Modalities:

   Remediation/Alternative Activities: Students reread the material. The teacher should assist the students in following the procedure for the first city, using an overhead transparency of the graph. Students should prepare the graphs on their own.

   Enrichment/Supplemental Activities: Students are to look up the rainfall and temperature each month for a year for their city and make a climatogram for their city.

7. Evaluation: The teacher collects and marks students' graphs, answers to follow-up questions, and independent practice exercises.

PRECIPITATION AND TEMPERATURE READINGS

DATA SHEET

P = Precipitation in centimeters

T = Temperature in degrees celsius

		J	F	M	A	M	J	J	A	S	O	N	D
Asheville, North Carolina	P	8.6	9.1	11.9	8.9	8.4	10.2	12.4	11.4	9.1	8.4	7.4	9.1
	T	3.0	4.0	8.0	13.0	18.0	22.0	23.0	23.0	19.0	17.0	11.0	7.0
Birmingham, Alabama	P	12.2	13.5	15.7	11.7	9.1	10.2	13.2	10.9	9.1	6.6	9.4	13.2
	T	7.0	8.0	12.0	17.0	22.0	25.0	27.0	26.0	23.0	17.0	11.0	7.0
Dodge City, Kansas	P	1.3	1.5	2.8	4.3	7.9	8.4	7.9	6.6	4.3	4.3	1.5	1.3
	T	0.0	2.0	5.0	12.0	17.0	23.0	26.0	26.0	20.0	14.0	6.0	1.0
New York, New York	P	7.4	7.9	10.2	9.1	8.6	7.4	9.9	11.4	8.1	7.6	9.7	9.1
	T	0.0	1.0	5.0	11.0	17.0	22.0	25.0	24.0	20.0	14.0	8.0	2.0
Miami, Florida	P	5.6	5.1	5.3	9.1	15.5	22.9	17.5	17.0	22.1	20.8	6.9	4.1
	T	19.0	20.0	22.0	24.0	26.0	27.0	28.0	28.0	28.1	26.0	22.0	20.0
Honolulu, Hawaii	P	11.1	6.4	8.1	3.6	2.5	0.8	1.5	2.0	1.8	3.8	7.6	9.4
	T	22.0	22.0	23.0	24.0	25.0	26.0	27.0	27.0	27.0	26.0	25.0	23.0

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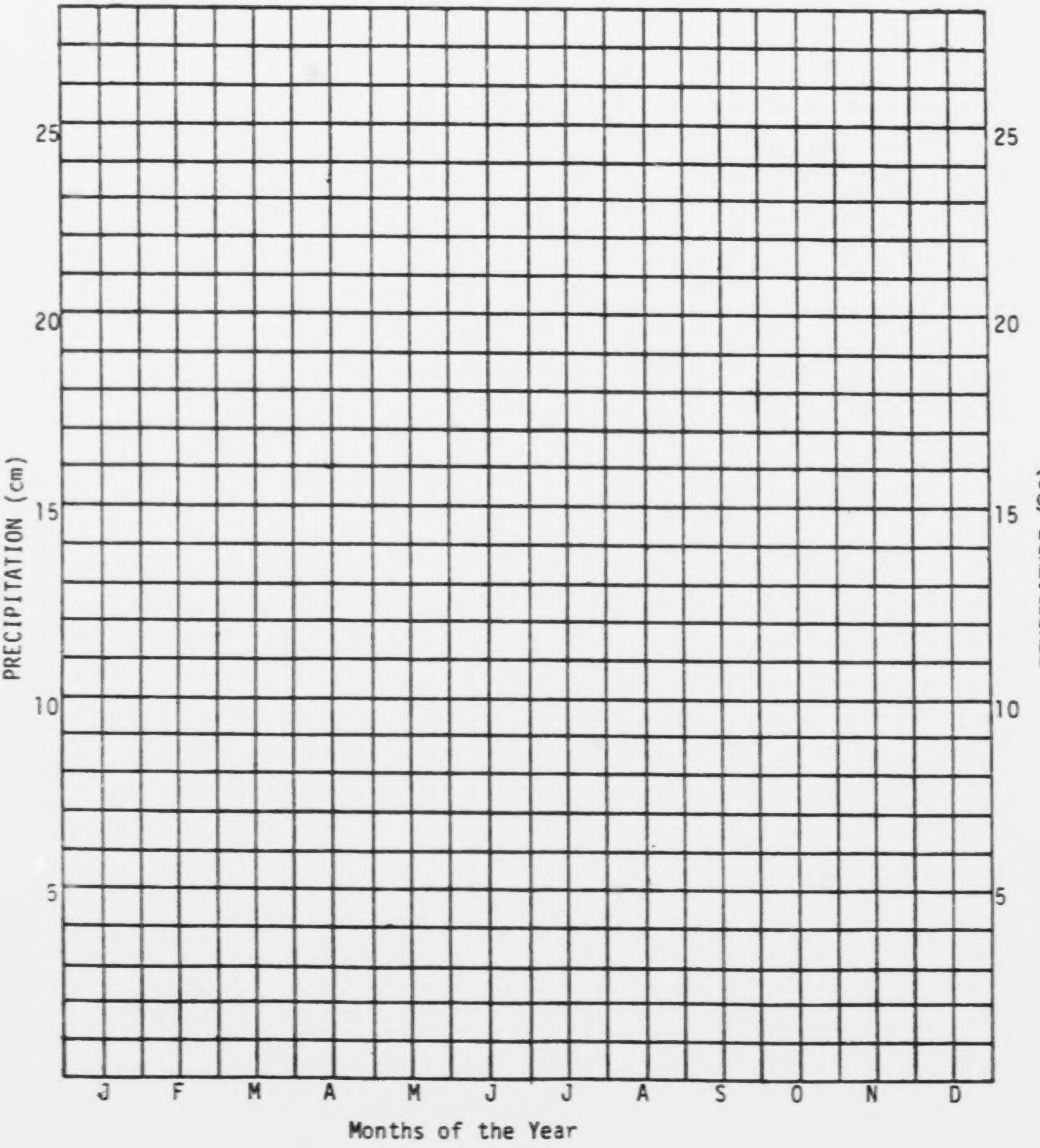
PRECIPITATION CALENDAR



SAMPLE LESSON X: SPECTRA ANALYSIS

COURSE: Physical and Earth Science AB

REPRESENTATIVE OBJECTIVE: The student will be able to assemble and use laboratory apparatus, tools and material in a skillful manner, giving due attention to safety measures.

SKILLS EMPHASIZED: Listening and speaking

THINKING/COGNITIVE SKILLS: Analysis

1. Specific Objective: Student will be able to identify the substance in an unknown sample by observing the spectrum it produces and comparing it with the spectra of known substances.

2. Value to Students: The student will be able to analyze an unknown sample by relating the knowledge he/she has about the composition of a known substance to the unknown material. The skill developed will help the student to do problem solving in everyday life.

3. Initial Instruction/Teacher Presentation: The teacher explains the process of using spectra to identify the composition of an unknown material though use of lecture/discussion and demonstration. The teacher should review materials, laboratory stations, safety procedures for the use of the bunsen burner, etc. before the start of the laboratory activity.

   Materials:
   "Tattle Tale Prints" (See page 106.)
   Ruler, colored pencils
   Various knowns and unknowns
   Bunsen burners, rubber tubing, wire loops
   Matches, shoebox spectrascopes (See pages 111-113 for directions for
     construction of spectroscopes)
   Data and worksheets (See pages 106-107)

   Examples of laboratory stations:
   1. White light
   2. Fluorescent light
   3. Neon tester
   4. Copper solution
   5. Sodium solution
   6. Nickel solution
   7. Strontium solution
   8. The sun (Caution students not to look directly at the sun.)
   9. Unknown A
      Made from mixtures of known solutions
   10. Unknown B

   (Solutions can be ordered from the Science Materials Center. They are included in the Flame Test Kit.)

4. Guided Group Practice: Students are to complete the "Tattle Tale Prints" worksheet on page 106-107 first. The teacher will continually check student work. Students are then to begin independent practice.

   When students reach the unknown stars, they are to use the information from the known stations to analyze the composition of the unknown stars.

   After completion of the lab, the students will answer the analysis questions.

5. Independent Practice: Students are to color in the continuous spectrum at the top of their data sheet. This spectrum acts as a guide. With the spectroscope, class members should next complete the laboratory sheets on pages 108-110. Caution students not to look directly at the sun or to hold the shoebox too close to the flame.

6. Individual Differences and Learning Modalities

   Remediation/Alternative Activities: The teacher reviews the initial activity sheet with students who do not understand the concepts. Also, students who work more slowly will work with students who are more capable.

   Enriched/Supplemental Activities: Students investigate and write reports on the uses of spectroscopy in the identification of elements in chemistry, astronomy, criminology, and other fields.

7. Evaluation: The teacher will mark the activity sheets and lab reports, including drawings and answers to the analysis questions. Students will be evaluated on how well their conclusions are supported by their actual observations. Observation of student activities during the laboratory work will also be used as an assessment tool.

TATTLE TALE PRINTS

Information:
Every substance in a star or galaxy gives off energy. Some of this energy is in the form of light which can be separated into different colors by a spectroscope. Each substance has its own color pattern of spectral light. The pattern is like a fingerprint, because it can be used to identify the substances.

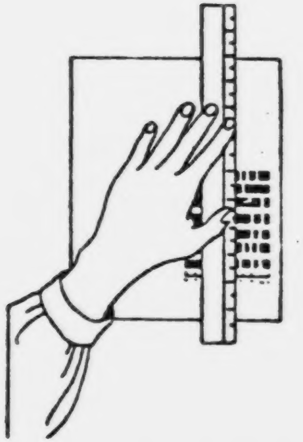
Astronomers focus a telescope on a distant star. The light from this star is passed through a spectroscope and is separated into its spectrum or pattern. By matching this pattern or fingerprint with that produced by a known substance or substances on earth, the astronomer can tell what the star or other astronomical object is made of.

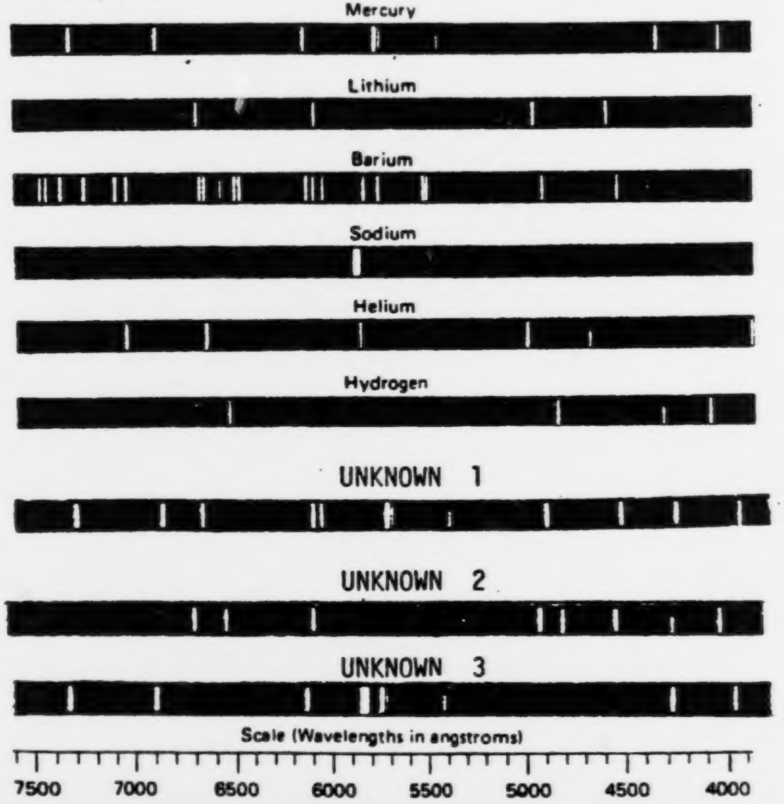
Procedure:
1. Using the chart of known and unknown spectra and your ruler, match any lines in unknown spectrum 1 with the known spectra.
2. List each substance or the substances contained in spectrum 1 by matching a known spectrum.
3. Repeat this process for the other two unknown spectra.

ACTIVITY

Materials

ruler or straight edge
pencil
paper




Mercury
Lithium
Barium
Sodium
Helium
Hydrogen
UNKNOWN 1
UNKNOWN 2
UNKNOWN 3
Scale (Wavelengths in angstroms)
7500
7000
6500
6000
5500
5000
4500
4000

(Continued)

QUESTIONS:

1. What substances are in each of the unknown spectra?

   Spectrum 1 Spectrum 2 Spectrum 3

2. What evidence do you have to support your conclusions? ______________________________

3. What problems might an astronomer face when using this method to identify the composition of stars? ______________________________

4. How might you find the composition of a newly discovered galaxy? ______________________________

NAME ______________________ PERIOD ________

IDENTIFYING ELEMENTS WITH A SPECTROSCOPE

Purpose: To identify and analyze certain known spectra, comparing them with unknown spectra.

Materials Needed:
Shoebox spectroscope
Colored pencils
Data sheets
Different sources of light

Procedure: Using the spectroscope, look at the different sources of light. On your data sheet, record the spectra you observe. Remember to draw your spectrum to scale. This will help you to identify the unknowns.

Look at the following lights:

1. white light
2. fluorescent light
3. Sodium (Na)
4. Neon (Ne)
5. Copper (Cu)
6. Nickel (Ni)
7. Strontium (Sr)
8. Unknown A
9. Unknown B
10. The sun

In chart form, record the type of spectrum each light source gives off. (See following page.)

Questions:

1. What is the source of a continuous spectrum?
   What is the cause of this type of spectrum?
2. What is the cause of a bright-line spectrum?
   Give two examples of bright-line spectra.
3. What is the cause of an absorption spectrum or dark line spectrum?
   Give an example of this type of spectrum.
4. What causes the dark lines in the spectrum?
5. What do these lines tell you about the object giving off the light?

IDENTIFICATION OF ELEMENTS WITH A SPECTROSCOPE

DATA SHEET

Record carefully your final conclusions, using your worksheet as a guide. Indicate with colored pencils spectral lines observed.

Known Continuous Spectra

1. White light							
2. Fluorescent light							
3. Hg ____________________							
4. Na ____________________							
5. Ne ____________________							
6. Cu ____________________							
7. Sr ____________________							
8. The sun							
9. Unknown A							
10. Unknown B							

THE UNKNOWNS

Look at two other light sources marked Unknown A And Unknown B. From your data, identify each element. On your data sheet, draw the unknown spectra and compare them to the other known spectra. Complete the following:

Unknown A is made of ______________________ because ____________________.

Unknown B is made of ______________________ because ____________________.

Analysis Questions:

1. What are some reasons why you may have come up with the wrong conclusions?

   ____.

2. When doing this experiment, what precautions did you have to take?

   ____.

3. List three things astronomers can find out about stars and galaxies by observing the spectra they give off.

   a. ____.

      ____.

      ____.

   b. ____.

      ____.

      ____.

   c. ____.

      ____.

      ____.

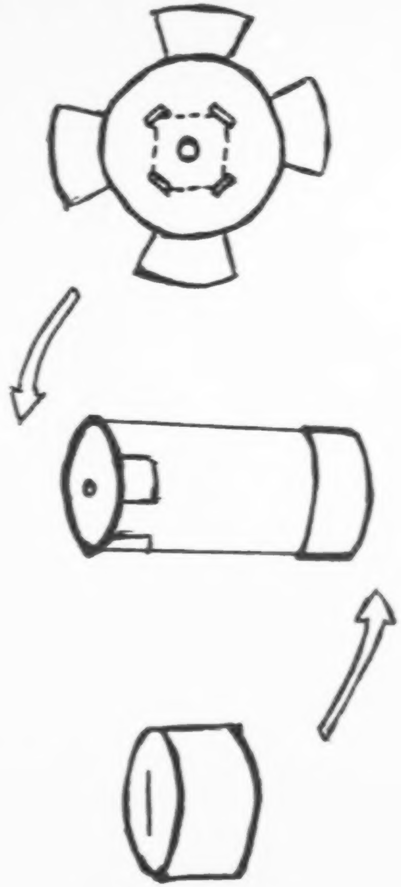
WHAT ARE SPECTROSCOPES?

SUPPLEMENTAL EXERCISE

A spectroscope is an instrument used by astronomers to examine heavenly bodies as to what elements are present, their temperatures, and also how rapidly they are moving.

A spectroscope consists of lenses and a prism. When light enters, a spectrum (band of colors) is formed by the prism. Each of the elements can be identified by the band of colors which it produces.

In this investigation, you will construct a simple spectroscope.



Materials:
Paper tube
Aluminum foil
Replica diffraction grating
Razor blade
3" x 3" square of construction paper
Masking tape
Scotch tape

Procedures:
1. Obtain a paper tube.

2. With your pencil, outline one end of the tube on a piece of construction paper. Add "tabs" to the circle. Cut out the circle with the tabs attached. In the center of the circle, punch out a small "eye hole," about the diameter of a pencil.

3. Tape a square of replica diffraction grating behind the eye hole with small bits of scotch tape. Fold the paper tabs of the circle around one end of the paper tube and tape the circle, so that the end of the tube admits no light except through the eye hole. Use masking tape.

SUPPLEMENTAL EXERCISE (Continued)

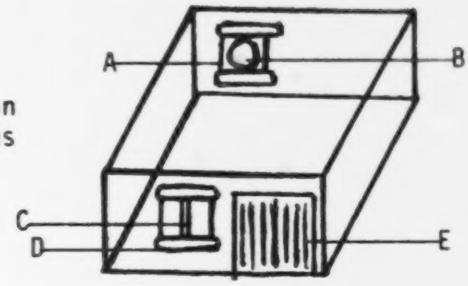
4. On the other end of the tube, place a square of aluminum foil so that it covers the open end. With a razor blade, carefully pierce the foil and draw the blade along a straight line to make a small, narrow slit.

5. Look at a light through the eye hole. Slowly turn the foil on the other end until you can see a band of colors.

SHOE BOX SPECTROSCOPE

Purpose: To show the details of construction of a shoe box spectroscope and to provide the teacher with information regarding the use of this device in the observation and determination of spectral lines.

Procedure:



grating lines run same direction as slit

spectrum seen on card

A - Replica diffraction grating in slide binder*
B - 20 mm eye hole
C - Slot 5 mm wide 25 mm long
D - Razor blades
E - White card with vertically ruled lines

Obtain a rectangular box (e.g., a shoe box or candy box). Cut an eye hole 20 mm in diameter at one end of the box and not more than 3 cm from the edge. Tape a piece of transmission type replica diffraction grating* (mounted on the inside of the box) across the hole. Cut a slot 25 mm wide near the edge at the other end of the box. Tape two razor blades over the slot (on the inside of the box) so as to form a slit 0.5 mm to 1 mm wide. The spectra formed by the diffraction grating will appear at E as well as on the other side of the razor blade slit.

Discussion: The shoe box spectroscope can also be used to make highly accurate determinations of spectral lines and wavelengths. This is a method for such use:

> A white card with vertically ruled lines is inserted in the area of the spectrum image to permit specific location of various spectrum bands and lines.

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* Replica gratings are available from the District Supply Catalog.

TEACHING STRATEGIES

A variety of instructional strategies can enhance the students' growth in both concept and skill development. Examples of these instructional strategies include:

- Teacher-directed lesson with the class investigating the same problem.

- Teacher demonstration with the class observing and recording observations and data.

- Independent study. Students conduct independent research and study concept or process areas. When completed, such individual work provides a basis for class learning projects.

- Team learning situations wherein two to four students function together as a laboratory investigation group. Interaction within and among groups acts both as a stimulus and an information-sharing aid to learning.

- Grouping of lower achieving students with those achieving at a higher level. This permits peer tutoring and interaction which can benefit the less motivated individuals.

- Contract between student and teacher which outlines and prescribes specific tasks to be performed by the student for the fulfillment of certain course requirements.

- Self-paced learning designed for mastery. Assessment is conducted as each student concludes each unit, and the results indicate whether a student is ready to advance to the next unit or experience--a repeated opportunity for the instructor to use a new strategy. Student's mark is based on number of units mastered.

- Library research studies wherein many of the principles learned in laboratory and class activities can be applied to a class, small group (team), or individual project.

- Class presentations by individual or laboratory teams on the outcomes of laboratory investigations which are shared with the class.

- Design and formulation of research projects. Individuals or teams apply the methods, material, and techniques learned to a real experimental investigation.

HIGHER LEVELS OF THINKING

Because questioning is the primary tool in achieving educational goals, teachers will want to be sure their questions are appropriate for the ability level of students and challenge students to higher levels of thinking.

Bloom[1] classifies six levels of thinking. They are:

- Knowledge (recognition or recall of previously learned material)
- Comprehension (translation or interpretation of data)
- Application (application of past learnings to a new situation
- Analysis (emphasis on the breakdown of material into constituent parts, the detection of relationships, and the organization of parts)
- Synthesis (organization of separate elements in a new creative structure)
- Evaluation (arrival at value judgments about a material or work)

The levels of thinking are sequential. In other words, each category of thinking is different and builds on lower categories. The categories are arranged from simple to complex and from concrete to abstract.

It is important that all students have many opportunities to answer questions involving every level of thinking. Within each category of thinking there are both simple and complex questions for slow and for rapid learners.

Questioning is particularly important during guided group practice in the teacher-directed lesson. Carefully constructed questions using various levels of thinking will help the teacher determine the students' comprehension of new material and assess their readiness to move on to independent practice. Individualization of instruction and remedial or alternative work can be achieved by constructing questions of varying levels of complexity.

Verbs alone do not necessarily determine the level of thinking. A given question may not represent the same task to all students. What may be an analysis question to one student may be a knowledge question to a pupil who has already read and received an explanation of the material. The level of a question depends on how much information the student has already received. If a student is expected to answer a "why" or "how" question by restating an answer provided in the textbook or from the teacher's lecture, the level of thinking is knowledge. If, however, the student has to figure out the answer, not simply remember it, the student is working on a higher level of thinking, such as analysis, synthesis, or evaluation.

Benjamin S. Bloom: Taxonomy of Educational Objectives: The Classification of Educational Goals, Handbook I: Cognitive Domain, (Longman Inc., New York, 1956).

Six categories of thinking and suggested verbs for teachers are provided below. Teachers will find these helpful in constructing questions and planning lessons. For further classification of learning levels in the affective and psychomotor domains, teachers are referred to *Reaching Higher Levels of Thought*, Los Angeles Unified School District, Office of Secondary Instruction, Publication No. X-118, 1982.

MAJOR CATEGORIES AND SUGGESTED VERBS FOR USE IN STATING COGNITIVE OUTCOMES

KNOWLEDGE

define
repeat
record
list
recall
name
relate
underline

COMPREHENSION

translate
restate
discuss
describe
recognize
explain
express
identify
locate
report
review
tell

APPLICATION

interpret
apply
employ
use
demonstrate
dramatize
practice
illustrate
operate
schedule
shop
sketch

ANALYSIS

distinguish
analyze
calculate
experiment
test
compare
contrast
criticize
diagram
inspect
debate
inventory
question
relate
solve
examine
categorize

SYNTHESIS

compose
plan
propose
design
formulate
arrange
assemble
collect
construct
create
set up
organize
manage
prepare

EVALUATION

judge
appraise
evaluate
rate
revise
score
assess
estimate
choose
measure
select
value

EVALUATION PROCEDURES

The evaluation of instruction is an integral part of the educational process. It provides information on what has been accomplished and where to go next. The first phase of evaluation should be diagnostic. The teacher should assess what students know before instruction, and then plan an appropriate course of instruction based on students' knowledge and abilities. In addition to diagnostic pretesting, ongoing evaluation during instruction provides teachers with a record of student progress and indicates the instructional changes that may have to be made in order to plan for maximum achievement. Post-testing assesses how well students have met the objectives at the end of the unit or course. The *Secondary Science Continuum* provides teachers with a basis for the development of instructional objectives.

The selection or construction of appropriate instruments of evaluation is critical to the measurement process. Test items must measure and reflect instructional objectives. Tests of achievement and problem-solving skills often require advanced reading skills. Therefore, it is recommended that diagrams, graphs, and pictures also be used to evaluate student progress and achievement.

Various measures of evaluation can be used in all phases of science education. Achievement tests assess science knowledge and comprehension. Problem-solving measures are useful for measuring higher cognitive skills such as analysis, synthesis, and evaluation. Motor skills and skill in the application of scientific knowledge can be evaluated in the laboratory setting. Observation and interview techniques are useful in the assessment of such laboratory skills as manipulating of materials, setting up experiments, handling and caring for live specimens, and employing safety practices. These measurement techniques allow for immediate feedback to students.

Suggested assessment procedures include the following: teacher-prepared tests; commercially-prepared tests; departmental tests; informal and formal assessment of individual and group activities in oral work and discussion; and student-prepared test items which provide reinforcement and the opportunity to apply course content.

TIPS FOR PARENTS

There are many ways in which parents can provide the proper guidance, motivation, assistance, and a nurturing home environment for their youngster's success and learning in science.

1. Show an active interest in your youngster's science learning activities. Take notice of and respond to science-related conversations, books, magazine and newspaper articles.
2. Be an observer. Offer assistance with a statement like, "We can discover by observation." This will stimulate and help your youngster to understand how knowledge develops through observation, thought, exploration, and verification.
3. Be a good listener, and discuss science interests and questions. This will help you learn more about your youngster's interests, thinking and reasoning abilities, and attitudes.
4. Read, review, and discuss homework and other class assignments.
5. Share experiences. For example, if you are an amateur gardener, mechanically inclined, a rock and mineral collector, etc., then you have something to share and to contribute to your youngster's developing curiosity about scientific interests.
6. Learn together. Encourage questions. Help your youngster locate sources of information and plan activities that provide opportunities for observing, experimenting, and recording data and the results of experimentation.
7. Practice scientific skills and attitudes. For example, help your youngster learn to withhold judgments until sufficient evidence has been secured, to challenge sources of information, and to be open-minded. These efforts will lead students toward the attainment of productive scientific attitudes.
8. Provide a quiet work and study area which can be used for homework and study, developing collections, experimenting, and making things.
9. Provide materials for learning, such as science-related books and magazines. Not only do they help students answer questions, but they also provide opportunities to experience the satisfaction of independent discovery.
10. Plan visits to museums, science fairs, observatories, zoos, national parks, open houses at universities, industry and governmental agencies, and other places of scientific interest.

11. Discuss with the teacher your youngster's progress, the specific learning needs which can be met through home study, and how your youngster might receive individualized help if needed.

12. Consult with the teacher and librarian about the selection of science-related books, magazines, and other materials available for reading. Become familiar with some of the scientific apparatus, displays, books, and audiovisual and other instructional materials used by the school.

13. Learn about the school's science program. Parental support of the school program is an essential factor in shaping positive attitudes toward education.

APPENDICES

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APPENDIX A

CLASSROOM TEST OF FORMAL OPERATIONS: TESTING AND SCORING PROCEDURES AND ANSWER KEY

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I. Introduction

This fifteen-item test has been developed and validated by Anton Lawson, Journal of Research in Science Teaching, 15(1), 11-24, 1978. Administration of the test requires apparatus like that described in the instructions. Details of the apparatus are not critical, however, because it is never used by the subjects but merely serves to illustrate the questions. Procedures for each test item are described below and are followed immediately by the material to be included in the students' answer booklets. Also given is the answer key. The item titles and spaces for answers and explanations should be assembled into booklets of one or two items per page, but omitting the answer key, of course. "Example" will be done by the class as a whole to introduce the students to the test procedure and the somewhat unusual form of the responses required.

II. GENERAL TESTING PROCEDURES

1. Students should be seated with empty seats between them if possible.

2. Pass out one test booklet to each student.

3. Provide the students with a general introduction to the test by explaining that the test consists of a number of demonstration items that lead to problems. Solution of the problems involves reasoning or problem-solving strategies that are useful in solving problems in a variety of areas. The test will provide information about how familiar you are with these strategies. Explain that some of the items are very easy and some quite difficult. Few students would be expected to get them all correct. Indeed, there may be a number of correct solutions to some of the items.

4. Have the students fill in the information on the top right-hand corner of the test booklet and then read the directions.

5. Explain that they will be progressing through the items as a class. This means that some students may finish some items before others and will have to be patient until all (or nearly all) of the other students have finished before going on to the next item.

6. Do the Example Item, "The Balancing Beam" with the class (see directions below). Have one student volunteer his answer and his explanation. Explain to the class that their explanations need not be lengthy but they should be complete. In this case, a complete explanation would be : "The weights are the same so the lengths should also be the same." Give the students time to write down their explanations and proceed to Item 1.

7. After demonstrating Item 1, give the students time to select an answer and justify their selection. Proceed to Item 2 when all but a few students have completed Item 1. You will have to use your own judgment about pacing as you progress through the rest of the items. You must go quickly enough so that the fast students do not become too impatient but you must go slowly enough so that the slower students have ample opportunity to respond. The entire test normally takes 75 to 90 minutes of class time in one long session or two shorter sessions.

8. It is important that the students understand the situations and the questions as best as they can. For this reason, you may need to repeat or rephrase certain questions and items of information for certain students. This is proper but care must be taken not to provide hints as to the correct solution.

III. SPECIFIC TESTING PROCEDURES FOR EACH ITEM

Example: "The Balancing Beam"

Materials:
One balance beam
Two 10-unit hanging weights

Directions: Show the students the balance beam and the two 10-unit hanging weights. Point out the equally spaced marks along the length of the beam and how the beam balances like a teeter totter when no weights are hung on it. Hang a 10-unit weight on one side of the beam at the 7th mark.

Ask: Where should the other 10-unit weight be hung to make the beam balance?

Item I: "Pieces of Clay"

Materials:
Two balls of clay of equal size, shape, and weight
One balance beam
Two balance pans

Directions: Show the students the two balls of clay. Point out that they are the same size and shape. Demonstrate that they weigh the same by placing them in the balance pans hung equal distances from the fulcrum of the balance beam. Remove the balls of clay from the pans and flatten one of them into a "pancake shape."

Ask: Does the pancake shape piece weigh more now? Do the two pieces weigh the same or does the ball weigh more?

Item 2: "Metal Weights"

Materials:
Two metal weights of equal volume but different weight (18 and 55 grams)
Two 25-ml graduated cylinders partially filled with colored water
One balance beam
Two balance pans

Directions: Show the students the metal weights. Point out that they are equal in height and in thickness. Place them on the pans of the balance beam to demonstrate their unequal weights. Point out the cylinders filled with equal amounts of colored water. Slowly lower the lighter weight into one of the cylinders. Note the rise in water level.

Ask: If the heavier weight were lowered into the other cylinder, would the water level rise higher, the same, or lower than it did in the cylinder with the light weight?

Item 3: "Plastic Cylinders"

Materials:
One wide plastic cylinder
One narrow plastic cylinder
One jar of colored water

Directions: Show the students the two plastic cylinders. Point out the different diameters and the equally spaced marks along the front of each. Pour water from the jar into the wide cylinder up to the 4th mark. Pour that water into the narrow cylinder and note that the water rises to the 6th mark. Tell the students to make a record of this information. Pour the water from the narrow cylinder into the jar. Pour water from the jar into the wide cylinder up to the 6th mark.

Ask: How high would this water rise if it were poured into the narrow cylinder?

Item 5: "The Pendulum's Length'

Materials:
Three strings numbered 1, 2, 3 suspended from a single support.
Strings #1 and #3 are of equal length, string #2 is longer.
Two 5-unit weights hung at the end of strings #2 and #3.
One 10-unit weight hung at the end of string #1.

Directions: Show the students the three strings and the weights. Attach the weights to the proper strings and explain that this makes three pendulums (just three strings with weights attached to their ends). Point out that pendulum #1 and #3 are the same length while pendulum #2 is longer. Point out that pendulum #2 and #3 have the same weight, but that pendulum #1 has a heavier weight. Swing one of the pendulums and count out loud each time the weight swings back to the release point. Point out that the pendulum seems to take about one second per swing.

Ask: Suppose you wanted to do an experiment to find out if changing the length of a pendulum changed the amount of time it takes to swing back and forth. Which pendulum or pendulums would you use for the experiment?

Item 6: "The Pendulum's Weight"

Materials: Same as for Item 5

Ask: Suppose you wanted to do an experiment to find out if changing the weight on the end of the string changed the amount of time the pendulum takes to swing back and forth. Which pendulum or pendulums would you use for the experiment?

Item 7: "The Balancing Beam 1"

Materials: One balance beam
One 10-unit hanging weight
One 5-unit hanging weight

Directions: Show the students the balance beam and the two hanging weights. Hang the 10-unit weight 7 marks out from the fulcrum on one side of the beam. Point out that the 10-unit weight is hanging at 7 marks from the center.

Ask: Where would you hang the 5-unit weight to make the beam balance?

Item 8: "The Balancing Beam 2"

Materials: One balance beam
One 15-unit hanging weight
One 10-unit hanging weight

Directions: Show the students the balance beam and the two hanging weights. Hang the 15-unit weight 4 marks out from the fulcrum on one side of the beam. Point out that the 15-unit weight is hanging at 4 marks from the center.

Ask: Where would you hang the 10-unit weight to make the beam balance?

Item 9: "The Spheres 1"

Materials:
One ramp
One target sphere
One heavy sphere
One light sphere

Directions: Show the ramp to the students. Point out that there are three spheres. One sphere is called the target sphere because it sits at the bottom of the ramp and gets hit by the other spheres that are rolled down the ramp. The other spheres (a heavy and a light one) are rolled from one of two positions - a low position half way up the ramp or a high posiiton at the top of the ramp.

Point out the low and high positions on the ramp and demonstrate how the spheres roll down the ramp, hit the target sphere, and cause it to move a certain measurable distance up the other side of the ramp.

Tell the students that you will describe one half of an experiment with the spheres and the ramp and, they will have to tell you how to complete the experiment. Have the students imagine an experiment in which the light sphere was released from the low position, rolled down the ramp, hit and propelled the target sphere up the other side of the ramp.

Ask: Which sphere would you release from the high position to find out if the place a sphere is released from makes a difference in how far the target goes?

Item 10: "The Spheres 2"

Materials:
One ramp
One light target sphere
One heavy target sphere
One sphere called Metal A
One sphere called Metal B

Directions: Point out the light and heavy target spheres and Metal A and Metal B. Tell the students that you will demonstrate an experiment and then ask them a question about the experiment.

Place the heavy target sphere at the bottom of the ramp. Hold Metal A at the high position on the ramp. Tell the students to imagine that Metal A rolls down the ramp and hits the heavy target and that the target moves a certain distance up the other side of the ramp (do not actually release Metal A). Now place the light target sphere at the bottom of the ramp. Hold Metal B at the high position on the ramp. Point out that this is the same position that Metal A was released from. Tell the students to imagine that Metal B rolls down the ramp and hits the light target and that the target moves a certain distance up the other side of the ramp (do not actually release Metal B).

Tell the students that when this experiment was actually done, Metal B hit its target farther than Metal A hit its target.

Ask: Does this experiment prove that Metal B can hit a target farther than Metal A can?

Note: Do not tell the students anything about the relative weights of Metal A and B.

Item 11: "The Metal Box"

Materials: One metal box with four switches, one black button, and a light bulb on it.

Directions: Point out the box, the switches, the light bulb and the black button. Point out that the switches are identified by four colors so that there is a "yellow switch," a "blue switch," a "red switch," and a "green switch." The switches can be flipped into either an "up position" or a "down position." If the correct switch or switches are flipped into the up position, and the black button is pushed, the bulb will light.

Cover the switches and flip the blue and green switches into the up position. Push the button to show the students that the bulb will, in fact, light if the correct switch or switches are flipped. You may need to flip other switches up and down again to assure that the students are not clued as to the correct combination. Flip all switches back to the down position and uncover them.

Explain that the objective of this puzzle is to discover which switch or switches must be flipped to make the light turn on. To do this they would actually need to use the box, but since there is only one box, they can only indicate how they would go about flipping switches to find out.

Show them how to use the symbols y, b, r, g, and the spaces labeled "Your Record" on their booklets by doing the example. Flip switch y (the yellow switch), push the black button, and note that the light remains off.

Explain that on each try the order in which the switches are flipped does not matter. For instance y, r and r, y are the same trial so they should not write down both.

Item 12: "The Shopping Center"

Materials: Four pictures of stores - a Barber Shop (B)
a Discount Store (D)
a Grocery Store (G)
a Coffee Shop (C)

Directions: Read the problem out loud. Show the students the four stores. Arrange them in the following way -- B D G C. Show them that this order corresponds to that indicated on the first line in the booklet. This means that the Barber Shop is in the first store location on the left, the Discount Store is in the second store location, the Grocery Store is in the third store location, and the Coffee Shop is in the fourth store location on the right.

Ask: Now write all other possible ways that the stores could be arranged, one arrangement per line. Note that there are extra lines in your booklet.

Item 13: "The Squares"

Materials: One cloth sack
Three yellow wooden squares
Three red wooden squares

Directions: Show the students the sack and the 3 yellow and 3 red wooden squares. Point out that each square is identical in size and shape. Place all the squares into the sack. Shake them up. Reach into the sack and select one piece (the first that you touch). Have the students imagine that you are going to pull this piece out of the sack.

Ask: What are the chances of pulling out a red square on the first try?

Item 14 "Squares and Diamonds 1"

Materials:
One cloth sack
Three red wooden squares
Five blue wooden squares
Four red wooden diamonds
Two yellow wooden diamonds
Three blue wooden diamonds

Directions: Show the students the cloth sack and the square-and-diamond-shaped pieces. Point out that all of the square-shaped pieces are identical in size and shape as are the diamond-shaped pieces. Place all of the pieces into the sack. Shake them up. Reach into the sack and select one piece (the first that you touch). Have the students imagine that you are going to pull this piece out of the sack.

Ask: What are the chances of pulling out a red piece on the first try?

Item 15: "Squares and Diamonds 2"

Materials: Same as for Item 14

Directions: Shake up the pieces once again. Reach in and select one piece (the first that you touch). Have the students imagine that you are going to pull this piece out of the sack.

Ask: What are the chances of pulling out a red diamond or a blue diamond on the first try?

IV. SCORING PROCEDURES

1. Each item is scored either correct or incorrect. Total test scores, therefore, may range from 0 to 15. Scores of 0-5 reflect concrete operational performance on the test. Scores of 6-11 reflect transitional performance and scores of 12-15 reflect formal operational performance.

2. To grade each item, compare the student answers and explanations to those shown on the ANSWER KEY. An item is correct only if the correct box is checked and an adequate explanation is provided.

V. ANSWER KEY

Name ______________________________ School ______________________

Birthdate ___________________________ Date ________________________
Month Day Year

DIRECTIONS:

For each of the items below a situation will be demonstrated. Each demonstration will lead to a question or questions for which there are a number of possible answers. For each item you are to check the box of the best answer and explain your choice in the space provided.

Example Item: "The Balancing Beam"

- ☐ Mark 3
- ☒ Mark 7
- ☐ Mark 8
- ☐ Mark 10

Please explain your choice.

Equal weights should be placed at equal distances from the center.

Item 1: "Pieces of Clay"

- ☐ The pancake weighs more.
- ☒ The pieces weigh the same.
- ☐ The ball weighs more.

Please explain your choice.

You did not add or take away any clay.

Item 2: "Metal Weights:

☐ The water will rise to a higher level.

☐ The water will rise to a lower level.

☒ The water will rise to the same level.

Please explain your choice.

The metal weights are the same size so they will displace equal amounts of water

Item 3: "Plastic Cylinders 1"

The water will rise to Mark:

☐ 7

☐ 8

☒ 9

☐ 10

☐ other

☐ There is no way of predicting

Please explain your choice.

$$\frac{4}{6} \quad \frac{6}{x}$$

$$4x = 36$$

$$x = 9$$

Note: Students do not have to use this method to be considered correct. Any indication of proportioned, rather than additive, reasoning is ok.

Item 4: "Plastic Cylinders 2"

The water will rise to Mark:

- ☐ 5 1/3
- ☐ 5 2/3
- ☒ 7 1/3
- ☐ 7 1/2
- ☐ 8
- ☐ 8 1/3
- ☐ 8 1/2
- ☐ 9
- ☐ Other
- ☐ There is no way of predicting

Please explain your choice.

$$\frac{4}{6} \quad \frac{2}{3} \quad \frac{x}{11}$$

$$6x = 44$$

$$x = \frac{44}{6} \qquad x = 7\,1/3$$

Item 5: "The Pendulum's Length"

Which pendulum or pendulums would you use for the experiment?

- ☐ 1 and 2
- ☐ 1 and 3
- ☒ 2 and 3
- ☐ 1, 2, and 3
- ☐ 2 only

Please explain your choice

Everything is the same except the length so you can tell if length makes a difference.

Item 6: "The Pendulum's Weight"

Which pendulum or pendulums would you use for the experiment?

- ☐ 1 and 2
- ☒ 1 and 3
- ☐ 2 and 3
- ☐ 1, 2, and 3
- ☐ 3 only

Please explain your choice.

Everything is the same except weight so you can tell if weight makes a difference.

Item 7: "The Balancing Beam 1"

Where would you hang the 5-unit to make the beam balance?

- ☐ Between Mark 3 and 4
- ☐ Mark 7
- ☐ Mark 12
- ☒ Mark 14
- ☐ At the end

Please explain your choice.

It's half the weight so it should be twice the distance.

Item 8: "The Balancing Beam 2"

Where would you hang the 10-unit weight to make the beam balance?

- ☐ Mark 5
- ☒ Mark 6
- ☐ Between Mark 6 and 7
- ☐ Mark 7
- ☐ Mark 8
- ☐ Mark 9
- ☐ Mark 10
- ☐ Mark 17

Please explain your choice.

The 10-unit weight is 2/3 of the 15-unit weight, so it must be placed 3/2's as far out. 3/2 x 4 = 6

Note: If a student uses the formula: $w_1 \times d_1 = w_2 \times d_2$ to solve the problem, this does not indicate the use of formal reasoning. The item should be dropped from consideration.

Item 9: "The Spheres 1"

Which sphere would you release from the high position to find out if the place a sphere is released from makes a difference in how far the target goes?

- ☐ The heavy sphere
- ☒ The light sphere

Explain your choice.

Since the light sphere was released from the low position, it would also have to be released from the high position or else you could not tell. It would be an unfair test.

Item 10: "The Spheres 2"

Does this experiment prove that Metal B can hit a target farther than Metal A can?

☐ Yes

☒ No

☐ Need more information

Please explain your choice.

The spheres hit targets of different weights so you can't tell anything about the two metals.

Item 11: "The Metal Box"

The objective of this puzzle is to discover which switch or switches must be flipped to make the light turn on.

Example:

	ON	OFF
1. y		X

y - yellow switch

b - blue switch

r - red switch

g - green switch

Your Record:

1. y
2. r
3. b
4. g
5. y, r
6. y, b
7. y, g
8. r, b
9. r, g
10. b, g
11. y, r, b
12. y, r, g
13. y, b, g
14. r, b, g
15. y, r, b, g
16. ____
17. ____
18. ____
19. ____
20. ____
21. ____
22. ____
23. ____
24. ____
25. ____
26. ____
27. ____
28. ____
29. ____
30. ____

Note: The combinations need not be in this order to be correct. There must be all 15 and no repetitions.

Item 12: "The Shopping Center"

In a new Shopping Center, 4 store locations are going to be opened on the ground level.

A Barber Shop, a Discount Store, a Grocery Store, and a Coffee Shop want to move in there. Each one of the stores can choose any one of the 4 locations. Write ALL THE POSSIBLE WAYS that the stores can occupy the 4 locations. Write on the lines below the letter B for Barber Shop, the letter D for Discount Store, the letter G for Grocery Store, and the letter C for Coffee Shop.

BDGC
BDCG
BGCD
BGDC
BCGD
BCDG
______
______

DBGC
DBCG
DGCB
DGBC
DCGB
DCBG
______
______

GBCD
GBDC
GDCB
GDBC
GCBD
GCDB
______
______

CBGD
CBDG
CGBD
CGDB
CDBG
CDGB
______
______

Note: The permutations need not be in this order to be correct. There must be all 24 and no repetitions.

Item 13: "The Squares"

Three yellow squares and three red squares are put into a sack. What are the chances of pulling out a red square on the first try?

☐ 1 out of 1

☒ 1 out of 2

☐ 1 out of 3

☐ 1 out of 6

☐ 2 out of 6

☐ 4 out of 6

☐ 3 out of 3

☐ Other

Please explain your choice.

3 of the 6 squares were red.

$\frac{3}{6}$ $\frac{1}{2}$

Item 14: "Squares and Diamonds 1"

Three red squares, four yellow squares, and five blue squares are put into a sack. Four red diamonds, two yellow diamonds, and three blue diamonds are put into the same sack. What are the chances of pulling out a red piece on the first try?

☐ 1 out of 1

☐ 1 out of 2

☒ 1 out of 3

☐ 1 out of 4

☐ 1 out of 21

☒ 7 out of 21

☐ 1 out of 7

☐ Other

Please explain your choice.

7 of the 21 pieces are red.

$\frac{7}{21}$ $\frac{1}{3}$

Item 15: "Squares and Diamonds 2"

Three red squares, four yellow squares, and five blue squares are put into a sack. Four red diamonds, two yellow diamonds, and three blue diamonds are put into the same sack. What are the chances of pulling out a red diamond or a blue diamond on the first try?

☐ 1 out of 1	☐ 8 out of 21
☐ 1 out of 2	☐ 9 out of 21
☒ 1 out of 3	☐ Other
☐ 1 out of 4	

Please explain your choice.

Four red and three blue diamonds = seven red or blue diamonds.

Seven out of 21 or one of three would be the chances.

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APPENDIX B

RESOURCES

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Teaching the Essential Skills. Los Angeles Unified School District: Office of Instruction, Publication No. GC-82, Stock No. 463818.

Test-Taking Procedures and Techniques for Secondary Schools. Los Angeles Unified School District: Office of Instruction, Publication No. X-116, Stock No. 463897.

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APPENDIX B: SECONDARY SCIENCE CONTINUUM

INTRODUCTION TO THE SCIENCE CONTINUUM, GRADES 7-12

PURPOSES

Science is the discipline which involves the acquiring and organizing of knowledge to explain natural phenomena and to increase their usefulness to humankind Through the science instructional program in secondary schools, students develop an understanding that science is a body of knowledge comprised of interconnected sets of principles, laws, and theories that explain the known universe and our relationship to it. Students use learning processes to systematically investigate phenomena and acquire and refine information. Outcomes include understanding how human beings use scientific information and discoveries to comprehend and practice the pursuit of objective knowledge as a source of truth.

COMPONENTS

The Science Continuum encompasses the four competency strands of attitudes, thinking processes, skills, and knowledge. Within each strand, the continuum includes objectives and the kinds of performance necessary for the student to achieve each objective. However, the continuum does not limit the scope of the science curriculum. Teachers should encourage students to progress to the extent of their interests and abilities. In the continuum, certain symbols are used. Items with a solid dot identify the expectancy level for all students. Those items without dots identify levels above those expected for all students. An open circle in the K-6 column indicates that certain items are first introduced to the student in elementary school.

Attitudes Strand. This strand emphasizes the development of values, aspirations, and attitudes which promote the personal involvement of the individual with the environment and society. The attitudes listed relate to what is huped students will accomplish, individually, through self-motivation, as a result of science instruction. Positive attitudes toward science and learning are prerequisites to effective learning in other strands.

Objectives of the attitudes strand include the ability of the learner to: internalize scientific attitudes; establish the personal and social relevance of what has been learned about science, scientists, and society; and enjoy and appreciate science.

Thinking Processes Strand. The goal is to help the student develop and apply rational and creative thinking processes. As defined here, these processes refer to the cognitive techniques involved in scientific inquiry as well as those basic to all rational thinking. Such processes as observing, measuring, comparing, and classifying lead to more sophisticated processes, such as inferring, generalizing, and theorizing.

Skills Strand. The goal is to help the student develop and use fundamental skills in the manipulation of materials and equipment, in caring for and handling living organisms, and in gathering, organizing, and communicating information relating to science. Various skills are utilized when the student employs thinking processes to develop a conceptual understanding of the natural environment and collects information through observation, manipulation of materials and apparatus, reading, listening, use of measuring instruments, and handling of living organisms. He or she employs linguistic, mathematical, graphical, and tabular skills in recording and organizing information.

A major goal of science education is the provision of opportunities for learners to develop and use these manipulative and communicative skills. Many areas of the curriculum relate closely to the skills that are critical to science education. Reading, writing, speaking, and listening skills are all basic to the communication needs of science students. Many of the skills described in the section are essential in a broad spectrum of occupations. For example, people in almost every occupation must be able to obtain, record, process, interpret, and report information and to communicate ideas in a clear, convincing manner. The skills goal is not only critical to science education, but it is also important in the development of competencies necessary for effective citizenship.

Knowledge Strand. The goal is to assist the student in developing knowledge of processes, facts, principles, generalizations, and applications -- the products of science -- and to encourage their use in the interpretation of the natural environment. Acquisition of organized knowledge is a long-range goal of science and science education. Through an understanding of contributing facts, unifying principles, and relevant processes, organized knowledge gradually takes on meaning for the learner. He or she will acquire some knowledge as a by-product of instruction intended to develop attitudes, skills, and thinking processes and will acquire other knowledge as a deliberate result of instruction. At all levels, the knowledge goal must be in balance with and consistent with the other goals of science education.

Four types of knowledge can be highlighted as components of this goal: (1) knowledge that enables the learner to communicate the thinking processes and skills of science; (2) knowledge that constitutes broad generalizations which interrelate the many facts, concepts, and principles of all the sciences; (3) knowledge of how science and technology affect society; and (4) knowledge that constitutes the content, basic concepts, and structure of the major disciplines in science.

IMPLEMENTATION

Through the in-service process, the teacher should become fully cognizant of the Science Continuum, its rationale, and its possible use. The goals and objectives of the continuum are basic to all science courses and are consistent with the provisions of AB 65 and the forthcoming State Science Framework. District-developed pretests and posttests are planned to assist teachers in evaluating each student's level of achievement in relation to the Science Continuum. The results of pretests should be used in planning instruction to meet more effectively group and individual needs. In addition, the teacher should formulate a variety of ways to assist the student needing additional instruction.

Approaches to instruction may include:

Development of learning centers
Assignment to independent study projects
Improvement of classroom management

Use of additional instructional resources
Introduction of changes in organization within the science department;
  e.g., use of minicourses, team teaching
Expansion of tutoring program
Improvement of counseling

Pretests and other tests prepared by the teacher should:

Be used to evaluate continuum goals and learner performance objectives.
Consist only of items based on performance objectives expected of all students.
Assess understanding of science concepts rather than reading ability.
Avoid items which are of a controversial nature with respect to individual religious or political beliefs.
Relate to life situations common to individuals in all cultural groups.
Involve problem statements with supporting data, as expressed in graphs, tables, pictorials, and other illustrations.
Wherever possible, relate items from skills, thinking processes, and attitudes objectives to knowledge objectives.

Test items related to attitudes should give the learner an opportunity to utilize knowledge applicable to the appropriate scientific attitude. This may or may not reflect the learner's personal attitude.

Test items related to thinking processes should be based on hypothetical problem-solving experiments and include questions that assess the student's understanding of scientific methods.

Test items related to skills should include questions about science apparatus, rules of safety, materials, and equipment common to both biological and physical sciences. Illustrations should be included.

SCIENCE CONTINUUM
GRADES 7-12

SYMBOLS
- - - - = Awareness/Exposure
0 = Introduction/Development
● = Assessment/Evaluation
—— = Maintenance/Reinforcement

1.0.0 ATTITUDES

		K 6	7	8	9	10	11	12
1.1.0	SHOWS CURIOSITY ABOUT OBJECTS AND EVENTS.							
1.1.1	Shows willingness to examine and organize objects and events in the environment.	0	—	●	—	●	—	—
1.2.0	RECOGNIZES AND REPORTS EVIDENCE OF ORDER AND SYMMETRY IN THE ENVIRONMENT.							
1.2.1	Relates classification to everyday life situations.	0	—	●	—	●	—	—
1.3.0	APPRECIATES AND RESPECTS ALL LIVING ORGANISMS, INCLUDING SELF AND HIS/HER RELATIONSHIP TO THE ENVIRONMENT							
1.3.1	Accepts responsibility for the care of living organisms in natural and artificial environments.	0	—	●	—	●	—	—
1.3.2	Appreciates the interdependence of living organisms in the natural environment and the implications for continued survival.	0	—	●	—	●	—	—
1.4.0	TAKES AN ACTIVE ROLE IN SOLVING SOCIAL PROBLEMS RELATED TO SCIENCE AND TECHNOLOGY							
1.4.1	Practices conservation in use of food, energy, and materials.	0	—	●	—	●	—	—
1.4.2	Develops and expresses an opinion on a social issue.	0	—	—				
1.4.3	Seeks to influence the views and behaviors of others with respect to social issues related to science and technology							
1.5.0	WEIGHS ALTERNATIVE SCIENTIFIC, ECONOMIC, PSYCHOLOGICAL, OR SOCIAL FACTORS WHEN CONSIDERING POSSIBLE SOLUTIONS TO SOME PROBLEMS							
1.5.1	Recognizes the alternative factors to be considered when examining possible solutions.	0	—	●	—	●	—	—
1.5.2	Examines a variety of alternative viewpoints on scientific issues to form opinions about them.							

ATTITUDES (CONT.)

	K-6	7	8	9	10	11	12
1.6.0 ORGANIZES AND REPORTS THE RESULTS OF SCIENTIFIC INVESTIGATIONS IN AN HONEST AND OBJECTIVE MANNER.							
1.6.1 Understands the need to log only those data he/she has actually gathered.	○—	—	●	—	●	—	—
1.6.2 Forms opinions only after seeking a variety of data and ideas.			●	—	●	—	—
1.6.3 Assumes responsibility for reporting results in an honest and objective manner.	○—	—	●	—	●	—	—
1.7.0 HAS A CRITICAL, QUESTIONING ATTITUDE TOWARD INFERENCES, HYPOTHESES, AND THEORIES.							
1.7.1 Shows an interest in responding to contradictions between data and theory.			—	—	—	—	—
1.8.0 APPLIES RATIONAL AND CREATIVE THINKING PROCESSES WHEN TRYING TO FIND RELATIONSHIPS AMONG SEEMINGLY UNRELATED PHENOMENA AND WHEN SEEKING SOLUTIONS TO PROBLEMS.							
1.8.1 Attempts spontaneously to describe an object or event that has attracted his/her attention.	○—	—	●	—	●	—	—
1.8.2 Applies science problem-solving techniques in everyday life situations.	○—	—	●	—	●	—	—
1.9.0 RECOGNIZES THE VALUES OF SCIENCE AS A HUMAN ENDEAVOR REPRESENTING ALL RACIAL, ETHNIC, AND CULTURAL BACKGROUNDS.							
1.9.1 Chooses to gather information and report on the contributions of all cultures to the scientific world.	○—	—	●	—	●	—	—
1.9.2 Acknowledges that race, sex, or nationality should not constitute a barrier to scientific study.	○—	—	●	—	●	—	—
1.9.3 Values the scientific contributions of human beings from varying cultural backgrounds.	○—	—	●	—	●	—	—

ATTITUDES (CONT.)

	K-6	7	8	9	10	11	12
1.10.0 CONSIDERS SCIENCE-RELATED CAREERS AND MAKES REALISTIC DECISIONS ABOUT PREPARING FOR SUCH CAREERS, TAKING INTO ACCOUNT ABILITIES, INTERESTS, AND PREPARATION REQUIRED.							
1.10.1 Values the abilities, interests, and preparation required for a science-related career.			●	—	●	—	—
1.10.2 Assumes responsibility for making a realistic decision about the pursuit of a science-related career.			—	—	—	—	—

2.0.0 THINKING PROCESSES

	K-6	7	8	9	10	11	12
2.1.0 DEVELOPS ABILITY TO GENERATE DATA BY OBSERVING, RECALLING, RECOGNIZING, IDENTIFYING, AND MEASURING.							
2.1.1 Examines objects carefully, using a combination of senses to collect and process data; derives meaning from the observation; recognizes the need to use simple instruments to aid the senses in collecting data.	○—	—	●	—	●	—	—
2.1.2 Determines the need to repeat observations as a means of improving reliability.	○—	—	●	—	●	—	—
2.1.3 Uses measurement procedures to improve accuracy of observations.	○—	—	●	—	●	—	—
2.1.4 Identifies changes in properties and rates of change.	○—	—	—	—	—	—	—
2.2.0 DEVELOPS ABILITY TO ORGANIZE DATA BY COMPARING, CLASSIFYING, RELATING, AND ORDERING.							
2.2.1 Perceives similarities and differences in a set of objects; separates a set into groups according to a single characteristic.	○—	—	●	—	●	—	—
2.2.2 Develops arbitrary classification systems wherein objects can be put into mutually exclusive categories; uses quantitative measurements as criteria for grouping.			—	—	—	—	—

THINKING PROCESSES (CONT.)

		K-6	7	8	9	10	11	12
2.3.0	DEVELOPS ABILITY TO APPLY AND EVALUATE DATA AND GENERATE THEORIES BY HYPOTHESIZING, PREDICTING, INFERRING, GENERALIZING, THEORIZING, EXPLAINING, JUSTIFYING, JUDGING, AND INTERPRETING.							
2.3.1	Examines environmental issues, pointing out contradictions and discrepancies in the positions of various groups.			—	—	—	—	—
2.3.2	Gathers own data to form own point of view, satisfying any former contradictions.	○	—	—	—	—	—	—
2.3.3	Recognizes contradictions and unusual events.			—	—	—	—	—
2.3.4	Designs experiments to produce specific data to support or refute a hypothesis.			—	—	—	—	—
2.4.0	PARTICIPATES IN SCIENTIFIC INQUIRY AT THE APPROPRIATE LEVEL.							
2.4.1	Defines a problem related to an unusual event.			—	—	—	—	—
2.4.2	Identifies data needed to test a hypothesis; designs an experiment to generate the data; records and organizes data; and evaluates the hypothesis in light of new data.			—	—	—	—	—

3.0.0 SKILLS

		K-6	7	8	9	10	11	12
3.1.0	ASSEMBLES AND USES LABORATORY APPARATUS, TOOLS, AND MATERIALS IN A SKILLFUL MANNER, GIVING DUE ATTENTION TO SAFETY MEASURES.							
3.1.1	Manipulates simple materials, apparatus, and equipment in a safe manner.	○	—	●	—	●	—	—
3.1.2	Demonstrates growth in the ability to manipulate more complex science materials and equipment.			○	—	●	—	—
3.1.3	Acquires and assembles appropriate science apparatus, materials, and equipment in order to obtain designated data.			—	—	—	—	—

SKILLS (CONT.)

		K-6	7	8	9	10	11	12
3.2.0	DEMONSTRATES PROPER TECHNIQUES FOR HANDLING AND CARING FOR LIVING ORGANISMS.							
3.2.1	Handles plants and animals carefully, following suggested procedures.	○	—	●	—	●	—	—
3.2.2	Provides an environment for plant and animal life that is conducive to the support of normal life functions.	○	—	●	—	●	—	—
3.3.0	GATHERS THE INFORMATION NEEDED FOR DEVELOPING OR TESTING INFERENCES AND HYPOTHESES BY MAKING PURPOSEFUL, OBJECTIVE OBSERVATIONS OF THINGS AND EVENTS.							
3.3.1	Makes purposeful, objective observations.	○	—	●	—	●	—	—
3.3.2	Determines the timing of a series of events.			—	—	—	—	—
3.4.0	GATHERS NEEDED INFORMATION, WHICH HAS BEEN GENERATED BY OTHERS, FROM A VARIETY OF SOURCES APPROPRIATE TO HIS/HER ABILITY LEVEL.							
3.4.1	Listens to the ideas of others.	○	—	●	—	●	—	—
3.4.2	Gathers information from science textbooks, reference materials, science films, and television.	○	—	●	—	●	—	—
3.4.3	Finds sources of information needed to solve a problem related to a specific topic.	○	—	●	—	●	—	—
3.5.0	RECORDS OBSERVATIONS ACCURATELY AND ORGANIZES DATA AND IDEAS IN WAYS THAT IMPROVE THEIR USEFULNESS.							
3.5.1	Orally describes a series of events that have taken place.	○	—	●	—	●	—	—
3.5.2	Tabulates information and uses tables.			—	—	—	—	—
3.5.3	Interprets graphs and displays data graphically.	○	—	—	—	—	—	—
3.6.0	COMMUNICATES WITH OTHERS IN A MANNER THAT IS CONSISTENT WITH KNOWLEDGE.							
3.6.1	In group settings, orally describes observations and answers questions.	○	—	●	—	●	—	—
3.6.2	Explains, either orally or in writing, the methods and procedures involved in carrying out an investigation.	○	—	—	—	—	—	—

SKILLS (CONT.)

		K-6	7	8	9	10	11	12
3.7.0	USES THE METRIC SYSTEM EFFECTIVELY.							
3.7.1	Counts, uses numbers, and balances objects on an equal-arm balance scale.	0		●		●		
3.7.2	Measures linear distances, using a metric ruler.	0		●		●		
3.7.3	Uses a balance to determine the mass of objects.	0				●		
3.7.4	Measures volume of liquids in a graduated cyclinder marked in metric units.							
3.8.0	APPLIES APPROPRIATE MATHEMATICAL CONCEPTS AND SKILLS IN INTERPRETING DATA AND IN SOLVING PROBLEMS.							
3.8.1	Calculates rates from data.							
3.8.2	Finds the mean and median of a series of measurements.							
3.8.3	Utilizes exponential notation to express very large and very small numbers.							
3.8.4	Determines degree of precision of measurement and quantities derived from measurements.							
3.8.5	Uses calculators and/computers to advantage in manipulating data and solving problems.							

4.0.0 KNOWLEDGE

		K-6	7	8	9	10	11	12
4.1.0	DEMONSTRATES KNOWLEDGE OF THE PROCESSES OF SCIENTIFIC INQUIRY.							
4.1.1	Distinguishes between trial and error and controlled investigations.	0		●		●		
4.1.2	Matches names of various processes and products of scientific inquiry with examples.							
4.1.3	Evaluates procedures in the inquiry process that have been omitted or inadequately performed.							

KNOWLEDGE (CONT.)

		K-6	7	8	9	10	11	12
4.2.0	DEMONSTRATES UNDERSTANDING OF BASIC GENERALIZATIONS, RELATIONSHIPS, AND PRINCIPLES.							
4.2.1	Identifies simple cause-effect relationships.	0		●		●		
4.2.2	Uses a cause-effect relationship to make a prediction.	0						
4.2.3	Recognizes that atoms are composed of electrons, protons, neutrons, and other particles.	0				●		
4.2.4	Recognizes that electrons are negatively charged and protons are positively charged.					●		
4.2.5	Illustrates that the number of atomic particles varies with each element.					●		
4.2.6	Recognizes that matter is composed of particles which are in constant motion.					●		
4.2.7	Describes interaction and reorganization of units of matter and their association with changes of energy.							
4.2.8	Recognizes the uses of fuels.	0		●		●		
4.2.9	Identifies examples of kinetic and potential energy.					●		
4.2.10	Identifies pairs of objects having similar properties.	0		●		●		
4.2.11	Describes systems of classification used to sort a group of miscellaneous objects.	0		●		●		
4.2.12	Recognizes that classification systems are developed by humans for the use of humans and are one way of helping to understand the basic organization and pattern of nature.			●		●		
4.3.0	DEMONSTRATES KNOWLEDGE OF RELATIONSHIPS BETWEEN SCIENCE AND SOCIETY.							
4.3.1	Gives examples of ways in which the use of scientific knowledge has affected society.	0		●		●		
4.3.2	Describes aspects of a society that tend to encourage or inhibit the advancement of science.							
4.3.3	Identifies types of data valuable in planning environmental changes.							

KNOWLEDGE (CONT.)

		K-6	7	8	9	10	11	12
4.4.0	DEMONSTRATES KNOWLEDGE OF SCIENCE-RELATED CAREER OPPORTUNITIES AND THE PREPARATION NEEDED.							
4.4.1	Compares the work performed by persons in science occupations.	0						
4.4.2	Identifies ways in which careers are science related.	0						
4.5.0	DEMONSTRATES KNOWLEDGE OF CONTRIBUTIONS TO SCIENCE AND TECHNOLOGY MADE BY MEN AND WOMEN OF VARIOUS RACES AND NATIONALITIES.							
4.5.1	Matches significant discoveries to persons responsible.	0						
4.6.0	DEMONSTRATES KNOWLEDGE OF THE RELATIONSHIPS OF SCIENCE TO OTHER AREAS OF HUMAN ENDEAVOR.							
4.6.1	Identifies how modern techniques of determining the age of specimens contribute to knowledge of earlier civilizations.							
4.7.0	DEMONSTRATES KNOWLEDGE OF WAYS IN WHICH ATTITUDES, THINKING PROCESSES, AND SKILLS CAN BE RELATED FOR USE IN PERSONAL DECISION-MAKING.							
4.7.1	Given a list of foods, identifies items that would constitute a nutritious, balanced meal.	0		●		●		
4.7.2	Given manufacturers' literature and consumer research data, selects an object on the basis of comparison of various factors.					●		
4.7.3	Uses data from scientific investigations in presenting a position on a political issue.							
4.8.0	DEMONSTRATES GENERAL KNOWLEDGE OF SCIENCE.							
4.8.1	Recognizes that a cell is the basic unit of structure and function of a living organism.	0		●		●		
4.8.2	Recognizes that all living organisms have the same life processes.	0		●		●		
4.8.3	Demonstrates a basic knowledge of the structures and functions of the human organism.	0		●		●		
4.8.4	Understands and describes living organisms that grow and develop in different environments.	0		●		●		
4.8.5	Recognizes that the sun is the source of energy for green plants and is basic to the growth and maintenance of living organisms.	0		●		●		

KNOWLEDGE (CONT.)

		K-6	7	8	9	10	11	12
4.8.6	Recognizes the importance of energy levels as related to ecosystems.							
4.8.7	Recognizes that living organisms utilize matter and return it to the environment.	0						
4.8.8	Describes examples of humankind's dependence on and interference with natural ecosystems.	0		●		●		
4.8.9	Recognizes that a living organism is a product of its heredity and environment.	0		●		●		
4.8.10	Recognizes that all forms of life are composed of the same elements in different DNA blueprints.							
4.8.11	Understands relationships of structure and function of living organisms to their environment.					●		
4.8.12	Recognizes that living organisms have changed over the ages and that some species are now extinct.	0		●		●		
4.8.13	Recognizes that the motion and path of celestial bodies are predictable.	0		●		●		
4.8.14	Describes the regular movements of the earth and moon.	0		●		●		
4.8.15	Demonstrates an appreciation and understanding of time/space relationships.	0						
4.8.16	Demonstrates knowledge of basic differences between planets, stars, the solar system, the Milky Way Galaxy, and the known universe.	0		●		●		
4.8.17	Cites some of the accomplishments in humankind's exploration of space.	0		●		●		
4.8.18	Demonstrates knowledge of the effects of moon and sun on ocean tides.	0						
4.8.19	Recognizes that matter exists as solids, liquids, and gases.	0		●		●		
4.8.20	Demonstrates that in chemical or physical changes the total amount of matter remains unchanged.	0		●		●		
4.8.21	Recognizes that in nuclear reactions a loss of matter is a gain in energy; the sum of matter and energy remains constant.							

KNOWLEDGE (CONT.)

		K-6	7	8	9	10	11	12
4.8.22	Recognizes that there are continuous changes on earth.	0		●		●		
4.8.23	Recognizes that rocks contain one or more kinds of minerals.	0						
4.8.24	Recognizes the three major types of rocks that make up the earth.	- - -	- - -					
4.8.25	Recognizes the value of using renewable energy sources instead of non-renewable sources.	0		●		●		
4.8.26	Identifies major factors that cause weather changes and patterns.	- - -	- - -					
4.8.27	Identifies the effect of weather on the local environment.	0		●		●		
4.8.28	Identifies the ocean as a major influence on weather.	0		●		●		
4.8.29	Recognizes simple machines and their functions.	0						
4.8.30	Understands the definitions and interrelationships of force, work, and energy.							